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Curriculum Development with an MBTI approach

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Abstract

This proposal will describe a study to find a science and/or social studies curriculum format that is a good match for students with each of four different learning styles. Using previous IQP's and other studies we will tie together former conclusions about MBTI types and how they perform in different assessments (such as MCAS). We hope to provide insight on curricula development so that all students can have an equal chance at learning the concepts and facts that represent literacy in a subject of study.

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1.0 Introduction

In 1993 Massachusetts passed the Massachusetts Education Reform Act, thus calling for the creation of the Massachusetts Comprehensive Assessment System (MCAS). Preliminary testing which started in 1998 on the class of 2000 showed that 50% of the commonwealth's students failed the test. Still in 2003, the MCAS became an official statewide test that every sophomore would have to take and pass before senior year, in order to receive their high school diploma. Students could take the test twice yearly in their junior and senior year, until successfully completing the exam. When practice testing began on the MCAS, the Worcester Public Schools decided to administer the Myers-Briggs Type Indicator (MBTI) instrument to those students who were taking the practice and the first official MCAS tests. The MBTI had also previously been used in a study involving students' PSAT and SAT scores from the Worcester Public School experience with the classes of 1996-1999. In the SAT study, there were striking differences in test scores associated with the Sensing (S) - Intuitive (N) and Judging (J) - Perceiving (P) dimension. Through the help of WPI students and the IQP program, the MCAS and MBTI data was combined. It allowed for the comparisons between students' performance on the first four MCAS Math and English subject tests, and their MBTI learning type. Controversy surrounded the Science and Social Studies MCAS and as a result they were not ready by 2001. This study showed that a certain MBTI learning type (SJ) was more likely to under perform on the MCAS tests than any other type, not only on the Math and English subjects, but also on the Science and History ones too. Our goal is to help improve the odds for success of the SJ learning type, by testing out different science curricula, looking for one that is especially effective for this learning style. The same approach can then be used for math and social studies education. Unfortunately, it is not clear to us how to apply these lessons to the teachings of English and Language arts.

Back in the mid 1990's many studies were done at WPI on an S-STS (teaching Science through the medium of Science, Technology and Society) curricula, and how different MBTI learning types responded to them. These curricula seemed to help improve the performance of the Sensing learning types. Through all of these studies many S-STS curriculum units were developed teaching several different science subjects. These S-STS curricula differ from a regular curriculum in that the curriculum teaches science as it comes up in examining the policy issues emerging out of some kind of societal question or problem. Thus, the study of science is motivated by its relevance to the learner and the general study would social consequences.

Our study involved creating two different 8th grade science curricula units with focus on the topics of NASA, the solar system, and the planets. While one of the curricula units was written in compliance with the traditional Massachusetts Curriculum Framework, the latter was developed with and S-STS curriculum format. The study then involved taking 48 college students, and dividing them into four groups of 12. The students were split up based on their MBTI dimensions being either: NP, SP, NJ, or SJ. From the 12 students per group, 6 read and responded to the traditional curriculum unit that was developed, while the other 6 read and responded to the S-STS curriculum unit. Finally from those 6 students taking each type of unit, 3 of the students' units included a lab, while the other 3 students' units did not have one.

The students participating in the study would have to put themselves in the shoes of an 8th grader, and respond to the curriculum units with a middle school mentality. Since WPI administers the MBTI instrument to almost all attending freshman, there was no need for us to administer the instrument to the student participants. Rather we only needed to provide the students with a consent form asking for permission to release the participating individual's MBTI learning type to our group.

The data received from the participants' responses to a set of survey questions, would then be used to evaluate the relative success of the different curricula, with the different kinds of learners. In the future this project could be assessed with a real 8th population, and could even lead to expanded project in which different curricula in many subjects could be tested to find the best curriculum format for each learning type. This would improve curriculum design and give students a more equal opportunity to do well in class, and later on in the MCAS.

2.0 Literature Review

WPI has a history of student projects concerning the MBTI, MCAS, and creating S-STS curricula for schools to use in order to benefit different types of learners. Many studies have been made to relate MBTI learning types to many different educational processes and outcomes, such as tests protocols and curricula formats. An example of this can be seen in the class of 2003 study, which compared the data from the MCAS scores and the MBTI learning types. The study concluded that a certain learning style (SJ learning style) seemed to be more likely to struggle on the MCAS regardless of the subject matter. On the other hand, students taking more challenging courses (Honors and AP) tended to do better on the MCAS as well. It was best to compare the learning styles of students who had the same preparations in high school. The MBTI then helped explain who was over or underperforming compared to their peers, i.e., who might fail the MCAS when their classmates generally passed, or pass when their classmates generally failed.

2.1 MBTI

The (Myers Briggs Type Indicator) MBTI instrument was developed through the efforts of Isabella Myers, and her mother Katharine Briggs, the authors of the Form A test type. The standard was Form G (having 126 of the 167 items from Form F) for many years. Now, Form M is the new standard, however WPI and the Worcester Public Schools always use Form G to control costs. The instrument, which is administered to at least two million people every year, was developed over a period of forty years. While first being developed in Myers dining room, the Educational Testing Service (ETS) later on gave her a base to develop it but refused to market it. The Consulting Psychologist Press took over that role in the 1970's.

The purpose of the MBTI instrument was to make Carl Jung's theory of psychological types understandable and useful for people in their everyday lives. The instrument can help individuals understand themselves better and become more appreciative of their surroundings. Jung believed that individual differences in personalities were based on the two human preferences of perceiving and judging. While perceiving entails absorbing information, the latter is oriented in organizing information and coming to conclusions. Jung also observed that some people seemed to be more energized by the external world; he classified this group as extraverts. While the people that seemed to be more energized by the internal world of what was going on in their minds fell under the introvert category. Jung's theory had 3 dimensions and also dealt with Dominant, Auxiliary, and Inferior functions.

After being re-developed by the mother and daughter team, the MBTI instrument composed of four scales, each consisting of two functions: Extraversion (E) - Introversion (I), Sensing (S) – Intuition (N), Thinking (T) – Feeling (F), and Judgment (J) – Perception (P). The J-P scale was to deal with the dominant and auxiliary functions. The strategy that Isabella and Katherine used was to posit that the differences would be expressed as preferences rather than behavioral absolutes. The analogy they used was right and left handedness. Hence, the MBTI items ask one to express a preference in social context, and out of social context tally up the proportion of times one responds as right or left in order to index a consistent pattern. An individual's learning type would then be determined by the preferences that he or she revealed when answering the 100 main and 26 research questions from the MBTI instrument; Answers are neither right nor wrong. Upon completion of the test, a numeric score is calculated for each preference chosen within the scales. The preferences with the highest score would then be an estimate of the individual's preferred function. The combinations of the individual's functions then yield one of sixteen possible four-letter codes, representing the participant's MBTI learning type. For example, INFP, indicates a person who is introverted, intuitive, feeling, and perceptive. The P indicates that N is the auxiliary and most visible to the outside observer, but the F is dominant.

The S-N functions get at how people process information, especially to the degree to which they are able and willing to read between the lines. T-F deals with how one comes to decisions based on the available information, especially the degree to which they will use empathy or rely on logic. Finally J-P deals with how predictable, structured, and organized the environment to operate in is preferred. *(In Appendix A, a chart can be found with the different scales and a short description of each.)*

2.2 MBTI & Learning Styles

According to the MBTI the sensing-intuition function is the one that is mostly linked to a person's learning style. A sensing learning type tends to learn best with practical and factual details, whereas the intuitive learning types tend to perceive with their memory and make associations. Since the intuitive types work out of their memory more, rather than their senses they tend to learn faster in classes. Most of the intuitive types will also perform better than sensing students in high school.

Another MBTI function that is related to a person's learning style is the thinking-feeling function. Thinking types tend to use a logical approach of reasoning, opposed to feeling types, who tend to use a personal approach of reasoning. Since thinking types use a logical approach of reasoning, they tend to do best in science and mathematics classes. On the other hand feeling types tend to prefer subjects that relate more to personal reasoning such as English or history classes.

2.3 MCAS

In the past couple of years the Massachusetts educational system has been evolved to adapt new curricula focused on providing students with the adequate knowledge to perform well on the Massachusetts Comprehensive Assessment Test (MCAS). After the Education Reform Law was passed in 1993, the new MCAS were introduced to test all public school students, and to report on individual, school, and district performance. The test was constructed to meet the standards for the Massachusetts Curriculum Framework, and to assess the four main topics of: English Language Arts, Mathematics, Science and Technology/Engineering, and History and Social Science. Almost ten years later, in 2003, 10th grade students across the commonwealth were the first to partake in the MCAS tests. Their results would determine the individual's eligibility for earning a high school diploma.

The MCAS comprises of four different question types: multiple choice, open response, short answer, and writing prompts. These different question types are each scored uniquely. The open response section is graded on a scale of 1 through 4, based on the MCAS guidelines that indicate how well a student has demonstrated his or her knowledge and skills for the corresponding subjects; spelling, grammar and punctuation are not factored into a students' open response score. The MCAS compositions are scored differently. Two different directors judge the students' answers based on topic development, and Standard English conventions. The topic development criterion is scored on a six-point scale, while the latter is graded on a four-point scale.

A few months after having completed the MCAS, the students receive their scores informing them of their performance for each subject tested. The highest general performance level is defined as advanced, where students have illustrated a comprehensive and thorough understanding of the subject matter, and have provided intelligent responses to complex problems. The second performance level, defined as proficient, entails that a student has demonstrated a good understanding of difficult subject matter, and was able to solve a wide assortment of problems. The next performance level is defined as needs improvement, where students have only demonstrated a limited understanding of the subject matter, and were not able to solve moderately easy problems. Finally, the last performance level defined by the MCAS is warning/ failing, where students have portrayed an insignificant understanding of the subject manner, and were not able to solve elementary problems.

Although the MCAS' purpose may seem opaque at first, the test's results can be used for many analytical studies. By analyzing various test results, the Massachusetts public schools will be able to improve teaching methodology and learning support, since parents, students, and educators will all be able to follow a student's progress. This will make it easier to identify the student's strengths, and weaknesses, and mark gaps in knowledge or understanding. This is especially important in cumulative subjects (like math) that build on past learning. Such diagnostic information can be used to improve student performance and help identify students in need of additional help. However, the MCAS will not only benefit the students, but also Massachusetts public schools as a whole. By studying a population's on school district's score, conclusions can be made on which curricula have gaps in them, and which ones need fine-tuning to meet statewide standards, and which systems are totally ineffective and should be completely reorganized.

2.4 MCAS – Science & Technology

The original Massachusetts Curriculum Framework for Science and Technology was divided into four content strands: inquiry; domain of sciences; technology; and science, technology, and human affairs. Later sciences, and technology and human affairs were moved to social studies, and the technology section focused on design issues at the request of physical science faculty statewide. Throughout the different content strands the students are to engage in solving problems, evaluating evidence, and searching for connections.

- *Inquiry:*

For the eighth grade MCAS test, the Inquiry content strand is broken up into the three main sections of: Designing an Investigation; Data Collection, Measurement, and Display; and Analysis and Interpretation of Data.

The goals for the *Designing an Investigation Inquiry* section are many. The first goals are to describe details, patterns, and relationships, and to differentiate between questions that can and cannot be answered through direct investigation. The next set of goals are to make predictions through the applications of personal experience and knowledge, and to design a problem specifying for variables to be either controlled, changed, and measured. The next goals are to address and analyze questions through the applications of different examination techniques. The final goals of the Designing an Investigation Inquiry section are to analyze alternative explanations and procedures, to communicate ideas and questions generated, and to suggest improvements or alternatives for experimental techniques that have been performed.

The Data Collection, Measurement, and Display section of the Inquiry strand has two main goals. The first is to use more complex tools to make observations and to gather and represent quantitative data. The second to represent data and findings using tables, models, demonstrations, and graphs.

Finally, the Analysis and Interpretation of Data section in the Inquiry strand has four main points. This first one is to describe trends in data, even if patterns are not exact. The next is to reformulate ideas and technological solutions based on evidence. Another is to communicate the idea that more than one solution exists in a technological problem. The final point of this section is to design a solution involving a technological problem, and to describe its advantages and disadvantages.

- *Domain of Sciences:*

The eighth grade Domain of Sciences content strand is composed of three sections: Physical Sciences, Life Sciences, and Earth and Space Sciences. The focus for this strand is to make sure that students have a clear understanding of the factual contents in the subject matter.

- *Technology:*

The technology content strand for the MCAS tests is composed of the Design Process section and the Understanding and Using Technology section.

In the Design Process section the first goal for the students is to identify and work on their own problems or ones developed by peers. Students are to explore and illustrate possible solutions and from those to propose one. They are to be able to make plans for building a device considering the limitations of materials, and are to evaluate designs, devices, or solutions with developed measures of quality. The final goal for the design process section is to communicate the process of technological design.

The technology education section comprises of many goals the following are a few examples. Students are to use tools, materials, and machines safely. They are to identify the processes used in construction. They should model the ways that multiple resources are used to develop new technologies, including people, information, tools, materials, energy, capital, and time. Students should also describe ways that technological advances may be accompanied by negative side effects. One last example is that students should be able to provide evidence that technology is growing at a faster rate today than ever before in history.

- *Science Technology and Human Affairs:*

The Science Technology and Human Affairs content strand focuses on five main goals. The first is to describe situations in which science, technology, and society have influenced each other in the past. To identify the influences that science and technology have on today's society. To provide examples that the decisions we make as individuals, groups, and communities can affect society and the natural environment and that these changes are not always easy to see, or positive in their effects. The next is to recognize and demonstrate that while technology can help us manage societal and environmental problems, it can also have negative impact on society and on the natural world. Finally, the section's last goal is to describe ways that technological devices have improved the quality of life for individuals.

2.5 S-STS

The goal of the S-STS curriculum is to teach students to look beyond the traditional way of thinking and learning, while furthering personal knowledge of the science curriculum and fulfilling the required knowledge needed to successfully complete the MCAS. Prior studies have proved that the S-STS curriculum format is a good method for personally involving students with the subject matter. It also allows for the students to search out new knowledge for themselves.

The S-STS curricula developed by the WPI community consist of three main goals:

1. Creating a more Technologically Literate Society.
2. Making science relevant to the students' lives.

3. Motivating less scientifically oriented students to continue to study science, thus preserving a rang of future career options.[1]

Through the use of the S-STS curricula teachers have developed a set of expectations and techniques for teaching the units. These techniques are as follows:

1. Order of presentation
2. Umbrella Concept for lesson format and organization
3. Team Teaching
4. Student Activities and Role-playing. [2]

The debate over the S-STS curriculum centers on the fact that it brings social concepts into the science study. Some teachers believe that the curriculum format focuses too much on the social aspects of science, and not enough on the specific technical content. On the other hand, proponents of the S-STS curriculum format argue that it provides students with a broader view of the information they are being taught, and by incorporating science to the students' daily lives assures that they see as important for them to learn and socially relevant to their role as citizens of a technological society. The S-STS format introduces public social values and social consequences as part of the science teachings partly to motivate students not interested in science, but also as part of citizenship training. Part of this debate focuses heavily on whether the NF learners will encounter and retain the same amount of information with the S-STS curriculum format as with the previous one. It also focuses on whether or not the learners of other types will

[1] Evaluation of the WPI 6th Grade STS Initiative, Maria A Salvati, 9/18/1996
[2] Evaluation of the WPI 6th Grade STS Initiative, Maria A Salvati, 9/18/1996

engage the science material as much as traditional INT learners, who seem to thrive on the traditional science curriculum.

Previous studies have found that the NF learners scored considerably better using the S-STS curricula, while the INT learners either improved or stayed the same. This teaching style clashes with the students' learning types for the sensing and intuitive types. Currently many teachers believe that that the science curriculum is looked upon as "a dull litany of vocabulary memorization and description." The S-STS tries to take the science and put it into the world of the students, getting them involved in order for them to visualize how the science relates to their everyday lives.[3] S-STS at its best is meant to be a hands on approach to teaching with activities that act out the issues in the unit; its goal is to have students take an interest in the material they are learning, and the "hands on" part is especially important when trying to engage the ES students who are in the majority and in elementary school, are the majority of the teachers too.

2.6 MBTI & S-STS

Previous IQP projects found that the intuitive learning style did fairly well with the current standard of teaching and the current curriculums, but the sensing type students were at a higher risk of not gaining as much knowledge from the current abstract and generalized science text and courses, especially if they were not "hands on." After more research and testing, some WPI project teams also found that with a new curriculum in place, the S-STS one, most of the sensing types showed a moderate improvement while the intuitive types did as well or better. The longer the S-STS experiment lasted, the more

[3] Introducing the Worcester Polytechnic Institute 5^{th}-7^{th} grade STS modules, WPI: Class of 1998; p. C-2, C-10

the Sensing type students improved, however most studies only tested one unit for about a month. The longest study involved two units and took three months to complete. In this study the Sensing type students once again improved with their overall scores, the intuitive types showed no loss in their test scores.

The debate over the S-STS learning style has been pushed into the limelight by the fact that many advocates believe that the traditional teaching style provides no instances for students to involve themselves in the technical side of the work and those that do rarely get to use the knowledge in an applied fashion. The negative aspect of the S-STS curricula is that it often brings a social studies aspect into the science and technology sections of the work. The traditionalists believe that students who learn with the S-STS curricula fail to see the relationship between what they are learning and how it interacts with all the other aspects of the subject. On both sides, it is agreed that the key is to turn students on to learning instead of turning them away. It is said, " an inquisitive student is a good student." Clearly the problem is that one size doesn't fit all. We need two or more parallel presentations pf the same science content and cant have that. We have to choose one. Do we choose what works best for the teacher the majority on the potential science stars.

Former WPI's IQP project groups have worked with various public school systems using very hands on approach. They have sometimes taken over classes, worked directly with teachers, have assisted teaching curricula, and have worked in the background scenes with teachers comparing student results from both the MBTI and

MCAS scores. Teachers and students have provided feedback on what they think would be a good curriculum, and what their experiences with the test curriculum were.

By administering the MBTI to participants and observing the number of students that are of a sensing learning style our focus will be to try to see if we can implement the S-STS teaching curriculum for the SJ and SP type most likely to struggle on the MCAS. We will be watching out for a potential cost to the NP's and NJ's in what we do to change the class. The S-STS teaching style is what seems to work in best for the SP's given what is currently known about the SP learning styles, however we think the SJ's will be ok with it. The ones that are sensing and have trouble with things taught in a more standard fashion are the focus.

The end goal of linking MBTI learner types with an STS unit is to improve students' performance on the MCAS in science and social studies, while providing them with the same science knowledge that would have been gained using a traditional unit. A more abstract goal of the STS is to help high school students master a well-rounded base level of knowledge to guide them through the real world upon graduation. MBTI data can benefit middle and high schools students, by helping the various learners retain the most knowledge from their educational experience. The MCAS is an accountability test that was designed to ensure that students have learned the bare minimum from their educational institution, before receiving a high school diploma. Even though "Advanced" scores are acknowledged by colleges and universities when offering scholarships to support a student's continuation with education, there is no reason for students to fail the MCAS due to handicaps based on their learning style. If a different learning style calls for different teaching approaches, schools should be obligated to accommodate a program to satisfy for an equal opportunity for all student to succeed in their classes.. No one can equalize the odds of doing really well on it.

2.7 Previous S-STS Curricula

While choosing an S-STS curriculum to try to help the SP's for our study we compiled all of the STS units that have been developed by the WPI community. All of these curricula can be used for our study. A short description of each unit can be seen below:

"The sun and earth and NASA" which has been already successfully tested at the Downing Street school in Worcester, MA. It originally was more of a traditionally taught unit, with standard organization, but has been revised to become a more complete S-STS format. Students seem to like this unit, and it has a wide overall appeal, which makes it a good candidate.

The second unit is the "electricity and the energy debate". This was the first unit developed at WPI. This unit is particularly interesting because it is able to have role playing games included in its teaching. This brings the material closer to home and makes the students take an active involvement in the material. The unit has been tested at Greendale elementary school.[4]

Third, "Medieval Technology: an arms race?" This physics unit was also tested at Greendale elementary school. Teachers of the classes have given it positive feedback. It

[4] Introducing the Worcester Polytechnic Institute 5^{th}-7^{th} grade STS modules, WPI: Class of 1998; p.32 (Lesson 15, Power)

involves large amounts of hands on activities, and participation. It is meant to make students think about history, technology, and present debates over arms races. It is considered to be a very successful and could be retested.

The fourth unit is "science and music: the art of acoustics". Originally developed in the Summerville school system in Massachusetts, the unit had needed to be retested due to errors in the questionnaire process. According to a previous IQP group, the unit is ready to be retested and will succeed in a trial.

The unit called "The sun, the Earth and NASA." Has also been field tested at the Downing Street School in Worcester Massachusetts. The previous group (Greg Shearman and Micheal D. Fontana) found that it lapsed into a more traditional style of teaching, but after revision, they now believe that it is ready to be re-tested in the more complete S-STS curricula style. Greg and Micheal found that Astronomy and NASA are popular subjects among students and is highly recommended for its overall appeal.

Lastly, the unit called "light, lasers and the eye: an S-STS Unit" which was originally tested in 6^{th} grade classrooms at Burncoat prep school in Worcester. It is an interesting unit because it provides an outlook in technology driving necessity or necessity driving technology. It also shows how technology VS safety debate can come close to home. [5] On the other hand the science is all over the place,

In the S-STS learning style, one example of the Astronomy units are taught by involving the students with the material directly. Students were asked to discuss their likes and dislikes about science and talk to one another about what their perceptions

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[5] Introducing the Worcester Polytechnic Institute 5^{th}-7^{th} grade STS modules, WPI: Class of 1998; p. 20-22

about science and scientists are. Topics about life without science are brought up and discussions on careers in science are talked about. These topics are there to give the students an idea of what it is to enjoy science and to want to be self-motivated in the furthering of their knowledge.

3.0 Methodology

The goal of this project is to establish prototype for the development of new type of curricula. It will cater to a different type of learner than the traditional ones, since the development of the MCAS everyone has to learn the fundamental concepts to graduate. In conclusion, the theme of this project is to produce an example of such a curricula for the SP and SJ learning types and see if its use will be at the expense of the NP and NJ types, or serve them just as well as the traditional one.

The purpose of the evaluation phase of this project is to generate useful information on how students with different learning styles perform academically after having been taught a curriculum in one of two different formats. More specifically, the goal is to improve the way the Sensing-Judging personality types learn, the ones that perform least well on the MCAS test. This study will focus on three varying elements: the participants' MBTI personality type especially the Sensing-iNtuitive and Judging-Perceiving dimension, the curriculum format being taught, and whether or not the curriculum unit included a lab. The focus of this project will be to help improve the MBTI learning styles that tend to struggle on this achievement test. Reactions will be gathered by questionnaire after the people of different learning experience their assigned curriculum unit.

Through this evaluation phase of the project we plan to show that the S-STS curriculum will provide an alternate presentation of the same information that helps a broader range of learning styles to comprehend the material making it a good basis for curriculum format design. While evaluating the S-STS curriculum we will also present that there exists a corollary where the more tangible material a curriculum has the more a student of the Sensing learning type can benefit from the curriculum. We also plan to show that S-STS curriculum format will justify the information presented in the curriculum because it relates the information presented to real world situations. The clearer the objective is in the curriculum and the more structured and systematic the skill or concept taught is, the more the unit will appeal to the Judging students. With all of these points of the curriculum defined we will show how the S-STS curriculum appeals to many different learning styles and should be used as basis for curriculum development.

3.1 Stimulus

The original proposal for this project did not envision using WPI students as participants in the study sample, but rather actual eighth graders and their teachers. The procedures for the proposed study also differed. *(The original proposal can be found in Appendix B)*

Originally we planned to administer the MBTI instrument to various 8^{th} – 9^{th} grade classes accommodating a total of approximately 150 students and their teachers. By doing so, an individuals' learning type would be determined. We hoped for this research project would be performed in Worcester, since numerous previous IQP studies have been administered locally. One school that interested us particularly was the Accelerated Learning Laboratory (ALL) School, where a theme-based curriculum uses technology to establishes a high academic standards for all students enrolled. In the ALL School, students from kindergarten through eighth grade are taught the subject matters more through projects than textbooks. The school's unique curriculum style seems to fit with the format of the S-STS curriculum.

The next step would have been to split the classes into two different groups: a control group, and an experimental group. To try to gain insight on how the curriculum would affect different learning styles we deliberately spilt the two groups into equal proportions. The students in the control group would be taught a particular science subject with the school's traditional curriculum, while the experimental group would be taught the same information that is presented in the traditional curriculum in a S-STS curriculum format. This part of the procedure would indicate how the Sensing-Perceiving and Sensing-Judging learning styles (the two that performed the least well on the MCAS) would respond to the different curriculum formats. It would also indicate whether or not the curriculum format influenced a student's ability to learn. Along with that, insight would be attained on students' performance relative to their teachers' learning style.

The teachers from the selected classes would continue teaching the curricula instead of any of the project members. This would have been the best option since it would eliminate new potentially biasing variables from entering the study through the appearance of the new teacher. After the two different curricula would have been administered to the different classes, the students would then be tested on the materials using items from past MCAS on that subject matter. The results on relative mastery would determine whether or not the study was successful. If the Sensing students did perform better while the iNtuitive students remained the same or improved, public schools could perform a similar study teach science curricula, and probably other subjects as well. Since the class of 2003, the MCAS has been a key factor for determining whether or not students will graduate from high schools; so other forms of assessment while potentially better would be considered irrelevant to the realization faced by the faculty and students. Performance on the form of achievements test is what matters now.

For this study any curriculum of the S-STS format can be used as the experimental stimulus, as long as there is a corresponding traditional curriculum for the control group. If the school does not have a S-STS curriculum unit there is one included in this IQP (*The S-STS curriculum can be found at appendix E*) based on the existing unit called "The Sun, The Earth and NASA," by Michel D Fontana and Greg Shearman. Any traditional curriculum that covers the same material as the corresponding S-STS curriculum could be used for the control group including the one in this IQP (*The Traditional curriculum can be located at appendix D*). Both curricula should be composed of the same number of lessons to ensure that the same amount of material is covered in both curricula. Also it is very important to make sure that both of the curricula cover key topics that would be covered in the MCAS.

Before the two different curriculum formats were administered, multiple meetings should be held with the IQP members and the participating teachers. The purpose of these meetings will determine which factors should be used to determine a student's academic progress, establish that both curricula cover the same material and to develop successful ways to collect progress data of individual students. Such factors could have included specific test scores, homework, group work, and more. During the implementation of the curriculum formats IQP students can observe different lessons to collect data on the students and teacher's behaviors. Regular meetings can be scheduled to evaluate the students progress based on the previous factors with the teacher and help prepare for the following lessons for the week.

Unfortunately, the Worcester Public Schools were not able to accommodate our study due to curriculum development staff changes, and time constraints from the 2003-2004 year schedule. After proposing this study to other schools in nearby towns in the form of a letter, we found ourselves with a lot of follow up calls to make and insufficient time to complete the project. Due to the fact that there will not be enough time to finish our project on time and we wanted to be able to test our hypotheses with some data, we were forced to re-design our strategy. *(The proposal letter sent to the public schools can be found in Appendix C)*

3.2 Strategy

Since we ran out of time to complete the full scope of the study, we devised a study that could be done using WPI students to evaluate different aspects of the curriculum. To be able to compare two different curriculum formats we needed to select an S-STS curriculum and find a corresponding traditional curriculum to administer to the group of students. In practice we updated and finished the S-STS curriculum " The Sun, The Earth and NASA," by Michel D Fontana and Greg Shearman and then created a new traditional curriculum which presented the same information. We then gathered a pre-selected population of 48 WPI students with an equal distribution of learning types. After splitting these students into a control and experimental group, the different curriculum formats can be administered. To evaluate how well each curriculum taught the WPI students the material we asked that each student fill out a survey keeping in mind that they would be presented this material as adolescent. The survey was composed of nine questions to help collect enough subjective data to determine if the S-STS curriculum format really did help the struggling learning types. (*The survey given to the students is located in Appendix G*)

To gather a sample population composed of WPI students we needed to come up with many different ways of recruiting people for our project. Our first attempt at recruiting students for the project was to compose a letter to the students of Professor Wilke's SS1207 class (*The letter sent to the students is located in Appendix F*). The class was required to take the MBTI test for their class, so our project was offered for extra credit. We also recruited fellow classmates to complete the test population. Since time was running short we ran a rolling deadline, to allow other students to participate in order to reach our goal population distribution.

	S-STS	Traditional	Total
Lab	3 Students	3 Students	6 Students
No Lab	3 Students	3 Students	6 Students
Total	6 Students	6 Students	

Figure 1 – Distribution of Curricula assigned

The goal population size of our study would be 48 participants, with 12 students each of the following types: Intuitive-Perceiving, Sensing-Perceiving, Intuitive-Judging, and Sensing-Judging learners. Of the 12 students from each MBTI type, 6 read and responded to the traditional curriculum unit that was developed, while the other 6 read and responded to the S-STS curriculum unit. Finally from those 6 students taking each type of unit, 3 of the students had a unit which included a lab, while the other 3 students' units did not include one. The motive for this was to see if the Sensing-Judging learning type, the learning type that struggled most with the MCAS, would find the curriculum beneficial.

The survey was created to help the students evaluate the curriculum. In the original plan student would have been evaluated on how much information they retained from the lessons. Since all of the students that would be reading our curriculum would of already have learned the information presented in middle school, a new evaluation had to be thought of. The survey was constructed to replace the testing part of the students. By carefully choosing the nine questions on the survey we can draw conclusions on which curriculum format performed better overall based on the combination of scores of different questions. The three variables we decided to measure the curricula on were:

1.) How informative the curriculum presented to be
2.) How relevant the curriculum was to real-world situations
3.) How much the students enjoyed reading over the curriculum

4.0 Results

4.1 Our Population

Our sample of the WPI population consisted of 47 people with a recorded MBTI learning type. We also administered the survey to 3 people for whom we had no MBTI data, hoping that their MBTI data could be collected at a later date. Since WPI's population of students is skewed to one learning type (iNtuitive-Perceiving) we were not able to collect an even distribution of learning types. Our sample showed a strong correlation to the distribution of the WPI population with roughly twice as many iNtuitive-Perceiving types than any other type. Even though our sample population was not ideal, the study can still be validated because we collected data for 11 students with a Sensing-Judging learning type. The Sensing-Judging learning type is the focus of our study since they are the least likely to succeed on the MCAS.

	S		N	
P	**SP**	9	**NP**	19
	ISTP	3	INTP	4
	ISFP	0	INFP	2
	ESTP	5	ENTP	7
	ESFP	1	ENFP	6
J	**SJ**	11	**NJ**	8
	ISTJ	5	INTJ	4
	ISFJ	3	INFJ	2
	ESTJ	3	ENTJ	2
	ESFJ	0	ENFJ	0

Figure 2 –Distribution of types by number

	S		N	
P	**SP**	19.15	**NP**	40.43
	ISTP	6.38	INTP	8.51
	ISFP	0	INFP	4.26
	ESTP	10.64	ENTP	14.89
	ESFP	2.13	ENFP	12.77
J	**SJ**	23.4	**NJ**	17.03
	ISTJ	10.64	INTJ	8.51
	ISFJ	6.38	INFJ	4.26
	ESTJ	6.38	ENTJ	4.26
	ESFJ	0	ENFJ	0

Figure 3 – Distribution of types by percentage

The only MBTI preferences that we focused on for our study were the Sensing-iNtuitive and the Perceiving-Judging preferences. This split our sample population into 4 learning type groups: iNtuitive-Perceiving, iNtuitive-Judging, Sensing-Perceiving, Sensing-Judging. Our main hypothesis will compare the results of the two opposite types Sensing-Judging and iNtuitive-Perceiving. The Sensing-Perceiving and the iNtuitive-Judging types are not as important in this study but help show how different curriculum formats affect all learning types.

It is apparent that our population was very different from what we expected. Even though this not the distribution we wanted, it worked well enough for our experiment. Both the Sensing-Judging and the iNtuitive-Perceiving types made up 63.8% of our population, giving us the most data for our main hypothesis. The iNtuitive-Judging and the Sensing-Perceiving make up the other 36.2% which will also provide us with enough data to test other hypotheses. With these numbers we will still be able to compare average numbers of different learning types.

5.0 Findings

This section will take the results from the data collected from our sample and compare it to our curriculum variables we defined in the methodology. We decided to measure three features of our curriculum formats to measure the overall success of the different curriculum formats with each type of learner. We will discuss each of these three variables we decided to measure our curriculum on:

4.) How informative the curriculum presented to be

5.) How relevant the curriculum was to real-world situations

6.) How much the students enjoyed reading over the curriculum

The instruction asked these college students put themselves back into their mindset in the 8th grade and to respond to the curriculum as they would of then.

How informative the curriculum presented to be

The first variable we measured was how informative each curriculum format was. This variable was measured comparatively, though we had labored hard to make sure that both curriculum units contained the same information. By measuring this we are looking for perception since we are assuring that both curriculum units present comparable information. The idea that one of the curriculum approaches sacrifices factual data to add social context is not relevant to this example. We controlled that variable.

Traditional

	S	N
P	SP 4.25	NP 4.88
J	SJ 4.50	NJ 4.60
	Total	4.64

S-STS

	S	N
P	SP 4.00	NP 4.36
J	SJ 4.80	NJ 4.00
	Total	4.40

Figure 4 – Scores to question 1 arranged by type

By looking at the following tables we can conclude that both curriculum were very close in how informative each format was. The overall score for the S-STS curriculum was 4.40 out of 6 and the score for the traditional curriculum was 4.64 out of 6. Even though the traditional scored a little higher than the S-STS curriculum we considered the two curriculums to be close enough on how informative they were.

How relevant the curriculum was to real-world situations

The next variable that was measured was the relevance of each curriculum format. The reason we measured this variable was that we wanted to see how each reader thought the curriculum related to "life training." Since this curriculum would be taught in early high school or late middle school, it is assumed that the information learned would be geared toward making the person a better citizen in the United States. This variable measures the relevance to show which curriculum better fits "citizen training."

Traditional

	S	N
P	SP 2.25	NP 2.13
J	SJ 2.00	NJ 3.20
	Total	2.44

S-STS

	S	N
P	SP 3.40	NP 3.55
J	SJ 3.80	NJ 3.33
	Total	3.52

Figure 5 - Scores to question 9 arranged by type

By looking at the following tables it is easy to see that the S-STS curriculum is a much better fit for "citizen training." The average score overall S-STS curriculum was 3.52 out of 6 where the traditional curriculum was only a 2.44 out of 6. This difference of 1.08 shows that the S-STS curriculum was significantly higher than the other curriculum format, making the S-STS curriculum a much better curriculum for a type of class that is geared toward preparing students to live in the United States.

How much the students enjoyed reading over the curriculum

This variable measured how well the user enjoyed the unit. This variable was measured using two measurements. The first measurement was how well the curriculum held their attention. The second measurement was how many things about the curriculum the person did not like. The first measurement shows how well the overall presentation of the material is to the reader, while the second measurement shows how many things the person really didn't like in each curriculum. These two measurements helped up deduce the overall enjoyment of the core curriculum.

Traditional

	S	N
P	SP 3.50	NP 2.88
J	SJ 2.33	NJ 3.80
	Total	3.04

S-STS

	S	N
P	SP 3.20	NP 3.55
J	SJ 4.20	NJ 4.33
	Total	3.64

Figure 6 - Scores to question 2 arranged by type

Traditional

	S	N
P	SP 1.75	NP 1.63
J	SJ 3.33	NJ 1.80
	Total	2.20

S-STS

	S	N
P	SP 1.60	NP 1.82
J	SJ 3.00	NJ 2.33
	Total	2.04

Figure 7 - Scores to question 4 arranged by type

The S-STS curriculum out-performs the traditional curriculum in both the two measurements for this variable. The overall performance for the S-STS on how well the curriculum held their attention was 3.64 out of 6. This is .6 higher than the 3.04 out of 6 average for the traditional curriculum. The S-STS curriculum format also outperformed the traditional curriculum in the second measurement with a score of 2.04 out of 6 to 2.20 out of six. Since the S-STS curriculum outperformed in both measurements we feel the readers enjoyed the S-STS curriculum more.

6.0 Discussion of Findings

In the following section we will use the findings of our study to discuss the hypotheses. In this section we will look at the three main hypotheses that we had 1.) The Sensing-Judging learning type group would find the S-STS unit more engaging and more informative 2.) The Sensing-type in general will benefit from the lab much and 3.) The iNtuitive-Perceiving learning type will find both curriculum formats equally informative and appealing.

After analyzing all of our data, we found certain expected trends that prove our theories. The Sensing-Judging learning type did not do as well with out traditional curricula. They much preferred the STS curricula, with its social commentaries and its broad usage of hands on activities. In our scores, the Sensing-Judging types gave consistently higher numbers vs. what they gave for the traditional curricula. A response to the STS curriculum from a Sensing-Judging type on the question what held your attention the most illustrative:

> "That which held my attention the most were the facts about the planets, and interesting facts such as the temperature of the sun, and how it produces energy. Also, the way that the information was structured made it seem more fun to learn"

Another Sensing-Judging response talking about the traditional curricula was "It had a lot of facts, but it wasn't very fun to read. Didn't grab me." This is an obvious difference in opinion between the same learning types. But it was also the average response for that type.

As was expected, the iNtuitive-Perceiving types had no apparent favorite; their learning styles allow them to effortlessly make a connection if the unit does not. They should get along equally well with either, and our data shows that. Their scores showed that the traditional seemed more informative to them but the S-STS held their attention more. The iNtuitive-Perceiving types were not even affected by the lab.

Our theory was that the Sensing-Perceiving types and the Sensing-Judging types would do better having some form of a hands-on lab, and we were proven correctly. Overall scores showed that the Sensing types like the curricula's with the labs better than without them. When asking to a Sensing-Perceiving type the question whether or not the lab would help reinforce the curricula the response was "Having a hands on look at the concepts really aids in learning"

Overall, we had a quite good consensus on our data. We were able to prove many of our theories through this study such as: iNtuitive-Perceiving types being impartial, Sensing types liking the STS curricula the most, and the iNtuitive-Judging types grasping a more traditional style curriculum where all of the facts are laid out in front of the student.

The S's did not like the traditional curricula very much at all, they all thought it was too dry and the facts laid out too straight foreword. This was to be expected with the Sensing types and on the flip side, the iNtuitive types seemed to like the Traditional, the bulleted laid out facts and straight foreword information were conducive to their learning abilities. The iNtuitive types did not like the STS curricula; it was not straight forward enough. "The information about the various space agencies just seemed to be useless information"

7.0 Conclusion

In conclusion we think that our study should take the next step and be administered in a real school program. There is sufficient evidence in this study that shows that the S-STS curriculum format may actually benefit a lot of the students that are struggling right now with the MCAS. Since the MCAS has become a graduation requirement it is imperative to make sure that all students have the same opportunities to pass the exam.

This study can be used as the basis of a bigger ongoing study that would involve the Worcester Public Schools. It would help provide some more insight on the way that curriculum developers currently develop the curriculum for these children. Also much of the planning of the design and implementation have been laid out in this report and can be used as a base for the study. The S-STS curriculum may not be the best curriculum developed, but it does appeal to more learning types than the traditional curriculum formats that are being used in public schools today. To get the a school district to implement this study would be a great benefit to the students and the curriculum developers themselves. Ultimately this study is trying to establish the science of developing curricula for a broad range of learning types and the S-STS is a step in that direction.

Appendices

Appendix A – Preference table

Preference Scales	
E: Extraversion *Preference for drawing energy from the outside world of people, activities or things.*	**I: Introversion** *Preference for drawing energy from one's own internal world of ideas, emotions, or impressions.*
S: Sensing *Preference for taking in through the five senses and determining what is actual.*	**N: Intuition** *Preference for taking information in through a sixth sense and noticing what it might be.*
T: Thinking *Preference for organizing and structuring information in a logical, objective way.*	**F: Feeling** *Preference for organizing and structuring decisions in a personal, value-oriented way.*
J: Judgment *Preference for living a planned and organized life.*	**P: Perception** *Preference for living a spontaneous and flexible life.*

Appendix B – The Methodology from the first implementation

The goal of this project is to generate useful information on how students with different learning styles perform academically and on the MCAS tests. This study will be based on three varying elements: a student's MBTI personality type, a teacher's MBTI personality type, and the curriculum style being taught. The focus of this project will be to help improve the MBTI learning style that tends to struggle on the science section of the MCAS test the most.

The first task will be to administer the MBTI instrument to various 8^{th} – 9^{th} grade classes accommodating a total of approximately 150 students and their teachers. By doing so, an individuals' learning type will be determined. Hopefully, this task can be performed in Worcester, since numerous previous IQP studies have been administered locally. One school that we are particularly interested in is the Accelerated Learning Laboratory (ALL) School, where their theme-based curriculum connects high academic standards for all students. In the ALL School, students from kindergarten through eighth grade are taught the subject matters through projects more so than textbooks. The school's unique curriculum style fits consistently with the STS one. In return, the ALL school provides a method for learning that has been proven to be helpful in solving problems, in integrating knowledge in the core disciplines, and in applying educational skills to the real world.

Normally the collection for MBTI data costs $10 per person, however we can save %70 of that cost by contributing our own personal labor. We are willing to pay for

150 students and their teachers with our $450 budget, if the school's can provide the Form G tests booklets. We can also perform the data collection logistics to the rest of the students and teachers in a particular grade, if the schools can just pick up the remaining tab. This means that for almost $3 per person, the individuals MBTI answers sheets will be sent to the *Center for Applications for Psychological Types,* in Gainesville Florida for processing. Within a week, the organization should be able to reply back with the results.

Administering the instrument will require 40 – 60 minutes of the students' time (teachers can complete it in 20 minutes). Even though this time is very valuable, the benefits gained from administering the MBTI test, outweigh the time that will be spent interrupting a class. After having attained the data sets, the information can then be used for a wide variety of studies. One fascinating study that can be done is to link the participants learning type with their MCAS score, and analyze the correlations. WPI can offer %75 chances for recruiting a future group to perform such further studies involving this year's data set.

The next step will be to split the classes into two different groups: a control group, and an experimental group. The students in the control group will be taught a particular science subject with the school's traditional curriculum, while the latter will use the S-STS curriculum to be taught the same subject matter. This part of the procedure will indicate how the SP and SJ learning styles (the two that performed the weakest on the MCAS) responded to the different curriculum formats. It will also indicate whether or not the curriculum format influenced a student's ability to learn. Along with that, insight will be attained on students' performance relative to their teachers' learning style.

The teachers from the selected classes will remain teaching the curriculum instead of our group. This is the best option because it would eliminate new variables from entering the study, which will produce more accurate results. After the two different curricula have been administered to the different classes, the students will then be tested on the material of the subject matter. The results will determine whether or not the study was successful. If so, many conclusions can be obtained on how public schools should teach certain curricula, and on how various learners comprehend the same subjects taught differently.

Since the class of 2003, the MCAS test has been a means for determining whether or not a student will graduate from high school. For the students' benefit, an STS curriculum relating to one part of the Massachusetts Curriculum Frameworks will be used.

If the school does not have any curricula in mind for us to use, the STS curriculum that will be conducted is "The Sun, The Earth and NASA," by Michel D Fontana and Greg Shearman. It is composed of ten lessons that provide insight to students on topics such as solar energy, the sun, stars, NASA, and more. This STS curriculum fits perfectly with Worcester's learning objectives for the science content, because it relates to a few different sections in the Earth and Space Science category. These sections include Systems and Interactions, Evolution, and Stability.

Before the two different curriculum formats are administered, a meeting will be arranged with the participating teachers, in order to determine which factors will used to determine a student's academic progress. Such factors can include specific test scores, homework, group work, and more. As the curriculum is being performed, each member from our group will attend one class a week to study the teachers' and students' behaviors. During this time, students' participation and behaviors will be recorded. At the end of each week, our group will conduct a brief meeting with the teachers in order to assess the students' progress based on the predetermined factors.

Through this project, we hope to establish a base for the development of new curricula, in order to increase students' academic potential. By performing better in class, students will also show improved results in the MCAS tests, creating it easier for them to graduate. In conclusion, the theme of this project is to produce and study curricula for the different learning types.

Appendix C – Letter mailed to the Worcester Public Schools

Janice Johnson, Director Of
Curriculum and Professional Development of Worcester Public Schools
and Manager of No Child Left Behind Program
20 Irving St.
Worcester, MA 01609

Dear Ms. Johnson:

I am one of three students working with Professor John Wilkes at WPI, on a study to find a science and/or social studies curriculum format that is a good match for students with each of four different learning styles. The four different learning styles (SJ, SP, NJ, and NP) can be identified using the Myers Briggs Type Indicator (MBTI). The focus on science and social studies is due to the existence of some successful curricula that mix the two subjects quite effectively, using social issues to motivate scientific and technological literacy.

We are seeking to perform our curriculum evaluation work in the Worcester Public School district, hopefully focusing on the 6^{th}-8^{th}-grade population. Our central goal is to help improve the performance of the SJ learning type that struggles most on the Massachusetts Comprehensive Assessment System (MCAS), giving them a better chance to succeed on the MCAS. However, along the way we hope to find curricula that are good matches for all four types of learners

Two previous series of studies provide a foundation for our proposal. The first was from 1992-1997, involving the development and evaluation of about a dozen S-STS (teaching Science through the medium of Science, Technology and Society) curriculum modules. They were typically evaluated using the MBTI as a learning styles measure, so we have some idea of whose performance improved the most on the S-STS units. The second began in 1998 when MCAS practice testing began in Worcester. At that time the MBTI was administered to the Worcester Public Schools classes of 2000-2003, and the results linked the students' learning type to their MCAS scores. These studies made it clear which types of learners were most at risk in terms of under performing on this required test. Compared to other students in high school classes of the same level of difficulty, the SJ's and especially the ESJ's were at greater risk of underperforming.

Our proposed study would involve taking three to five classes of 7^{th} or 8^{th} grade students and administering the MBTI instrument to them. The classes of students would then be divided into experimental and control groups. The experimental group would then be taught using S-STS curricula designed to suit or enhance the ease of learning for a type of learner learning. The control group would be taught the standard curricula that was not structured to suit a certain learning style, but might be biased towards one type of learner inadvertently.

For your convenience, we can build this project around any of the school system's current studies involving various curricula. Alternatively, we can use one or more of the WPI curriculum units, that teach the concepts of science through the context of social issues and social problems. You may already know that the S-STS curriculum modules designed at WPI in the mid 1990's, tended to improve the grades of the ESF learning types. The learning type that most frequently struggles on the MCAS tests is the SJ. However, other S-STS units, such as Chemcom (Chemistry in the Community), which was developed by the American Chemical Society for high school students were more successful with ENF learners. We think the key difference in the response of S and N students is whether the science concepts are introduced first or the social issue is covered first, to frame the unit. Previous studies have shown that N types do tend to do better with abstractions, but our theory is only plausible since it has not been tested. Finally, this study can help give insight on how to develop science curricula for all the kinds of students to reach a sufficient level of science mastery to perform well on the MCAS. We want to do this while enhancing their social studies background as well, at least for those types that are comfortable with mixing subjects in ways that increase the complexity of the materials.

In closing we would like to schedule a meeting with you to discuss the options that you would consider setting up a project in the Worcester School District. The possibility of working in the ALL school, where learning styles are taken very seriously is appealing to us. The numbers of students there are such that we might be able to profile all students grades 8-12, using the MBTI, without exceeding our modest budget of $450.00. We would need financial assistance to profile more than 150 students even if the Worcester Public Schools provide us with their reusable MBTI and we would only have to buy the answer sheet.

We intend to bring a rough copy of a proposal booklet that we would present to you at the meeting. I would like to thank you for taking the time to read our letter and I look forward to hearing from you.

Sincerely,
Matthew Racki
85 Salisbury St.
Worcester, MA 01609

cc: Siobhan Petrella - Social Studies Curriculum Liaison
Joseph Buckley - Science Curriculum Liaison

Appendix D – Traditional Curriculum

Introduction:

This is the traditional curriculum format based on the Sun, the Earth and NASA. It will be structured in a 10 lesson format that will span over 31/2 weeks (3 lessons a week). The lesson format will be based on a traditional curriculum format which will:
Introduce the abstract concepts.
Apply the abstract concepts to some kind of social context to reinforce the information
Will include a hands-on lab to help solidify the concepts to the students.

Lesson 1:
Introduction to the Solar System
Lesson 2:
The Sun
Lesson 3:
Mercury and Venus
Lesson 4:
The Earth
Lesson 5:
Mars
Lesson 6:
Jupiter and Saturn
Lesson 7:
The Outer Planets
Lesson 8:
The Different Space Organizations
Lesson 9:
Manned vs. Unmanned Space Travel

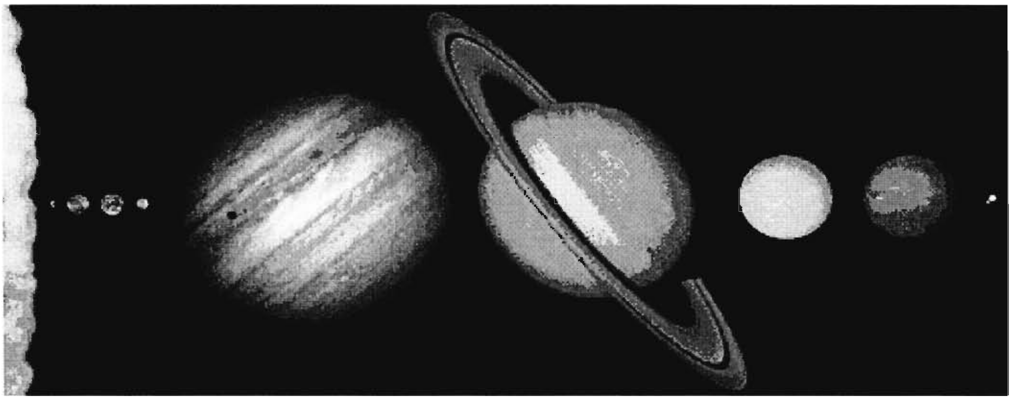
Lesson 1
Introduction to the Solar System

Key Terms
Asteroids
Comets
Copernicus
Eccentric
Ecliptic
Focus
Galileo
Geocentric
Heliocentric
Inner Solar System
Interplanetary Medium
Main Asteroid Belt
Meteor
Meteorite
Meteoroid
Natural Satellites
Orbit
Outer Solar System
Small Bodies
Solar System
Volatiles

Lesson Material

The solar system consists of the Sun, the nine planets, the planets' natural satellites (moons), a large number of small bodies (comets and asteroids), and an interplanetary medium. The inner solar system is made up of the Sun, Mercury, Venus, Earth, and Mars, while the outer solar system consists of Jupiter, Saturn, Uranus, Neptune, and Pluto.

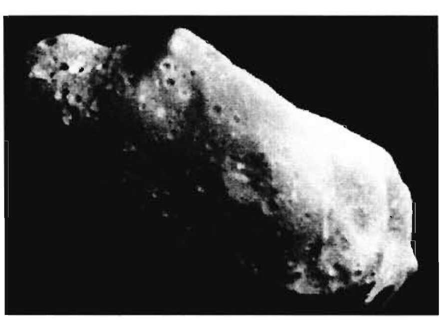
Each planet circles the Sun in an elliptical pattern, the Sun is known as the focus. The paths the planets use when traveling around the focus are referred to as orbits. The term eccentric is often used to describe an elliptical pattern. For instance, even though all the planets have eccentric orbits, Mercury's and Pluto's are very near circular, and much less eccentric than the other seven planets. Besides Pluto, the orbits of the planets lie more or less on the same plane, known as the ecliptic, defined by the Earth's orbit. While the ecliptic is inclined 7 degrees from the Sun's equator plane, Pluto's orbit is inclined 17 degrees.



The planets in their corresponding orders, and relative sizes.

This notion of the Sun being the center of the solar system was not always accepted. In the 16th century Nicholaus Copernicus, a Polish church official who had a passion for astronomy, proposed a heliocentric system, where the Earth and the other planets orbited the Sun. This contradicted the church's geocentric belief that the Earth was the center of the universe, and that the Sun orbited the Earth. Being associated with the church, Copernicus had to keep his views secret, and so he only published his ideas during the end of his life. One hundred years after his death, an Italian scholar by the name of Galileo observed that the planets and Earth were heliocentric. After aggressively defending Copernicus' theory, the Catholic Church quickly turned against Galileo. In 1633 he was condemned to life long imprisonment, but his sentence was carried out sympathetically and amounted only to house arrest. After that many more people started making the claim of the heliocentric theory until the church adopted the theory.

There are thousands of known asteroids and comets, and many more unknown ones. While most asteroids orbit around the Main Asteroid Belt, which lies between Mars and Jupiter, some asteroids have occasionally been found to orbit outside this belt, and others inside it, carrying them close to the inner planets. Most comets have highly eccentric orbits, and spend most of their time in the outer parts of the solar system; only briefly do comets pass close to the Sun.



Asteroids are rocky and metallic objects that orbit the Sun, however they are too small to be considered planets. They have diameters as large as 1000km, or as small as a small pebble. Asteroids are most likely the material left over from the formation of the solar system. When an asteroid is on a collision course with the Earth, it is called a meteoroid. When a meteoroid strikes the Earth's atmosphere at a high velocity, the friction of the atmosphere causes a streak of light known as a meteor. If the meteoroid has not burned up completely while crossing the earth's atmosphere, the remains left on the Earth's surface are called meteorites.

Comets are small irregular shaped bodies that are made up of different frozen volatiles, substances such as helium, water, carbon dioxide, hydrogen, ammonia, that are gasses at ordinary temperatures. They have highly elliptical orbits that bring them close to the Sun, and swing them deep into space, often beyond Pluto's orbit. All comets develop a surrounding cloud of diffuse material called the coma. Inside the coma lies a bright nucleus, comprising of mostly ice and gas with a small amount of dust and other solids. The coma and the nucleus together make up the head of the comet. As comets approach the Sun they break up and develop luminescent tails that travel many kilometers behind the comet's head. After many passes near the Sun, a comet's ice and gas is lost leaving behind a rocky object that resembles closely to an asteroid.

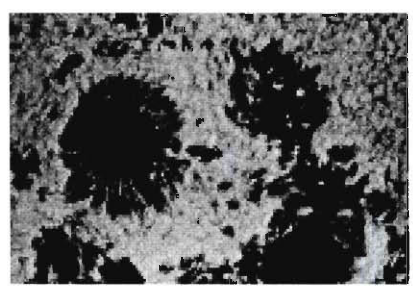
Finally the interplanetary medium is the appearance of an empty void that separates the comets, asteroids, sun, planets, and moons from one another. This vacuum of "space" includes various forms of energy and at least two material components: interplanetary gas, and interplanetary dust.

Lesson 2
The Sun
Key Terms
Chromosphere
Convection
Corona
G2
Gamma Rays
Nuclear Fusion
Photosphere
Planetary Nebula
Prominence
Sun
Sunspots

Lesson Material

The solar system consists of the Sun, and nine planets that orbit around it in an elliptical pattern. The sun is a normal main sequence G2 star, one of more than 100 billion stars in our galaxy; it is the largest object in our solar system, and contains almost 99.8% of our solar system's mass. The sun is in the top 10% of stars by mass, and is more than twice as big as the median stars of our galaxy. Having a size 110 times larger than that of Earth, the Sun is composed of 70% hydrogen, 28% helium, and about 2% carbon, nitrogen, oxygen, and traces of other elements.

The Sun's outer visible layer is called the photosphere where temperatures reach 6,000 degrees Celsius. This layer has a streaky appearance because of all the turbulent eruptions of energy at the surface. Sunspots are also visible on the photosphere; they are "cool" regions that look dark in comparison to their surroundings. Sunspots are not very well understood, but scientists believe they are a result of interactions with the Sun's magnetic field. Above the photosphere lies another layer known as the chromosphere, and above that rests the Corona, which extends millions of kilometers into space. The Corona is the outer part of the Sun's atmosphere; it is in this region where prominences, eruptions of immense glowing gas clouds, appear.

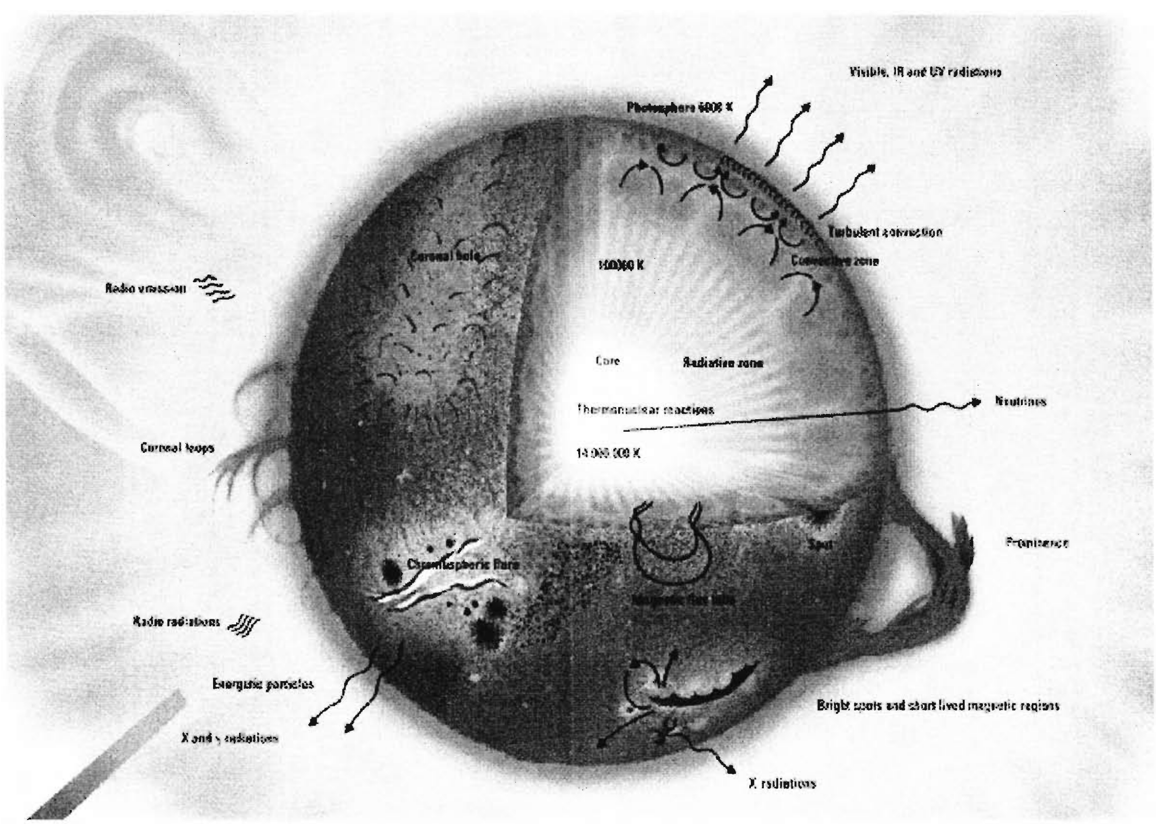


Sunspots of the Sun

Deep in the Sun's core, energy is produced through a process called nuclear fusion. During each second, about 700,000,000 tons of hydrogen are converted to about 695,000,000 tons of helium, and 5,000,000 tons of pure energy are created in the form of gamma rays. More specifically the nuclear reaction causes four protons or hydrogen nuclei to fuse together and form one alpha particle or helium nucleus. The alpha particle is about 7% less massive than the four protons, and the difference in their mass is expelled as energy that travels to the surface of the sun. The energy is continuously absorbed and re-emitted at lower and lower temperatures, so that by the time it has reached the Sun's surface, the energy has formed into visible light. For the last 20% of the energy's path to the surface, the energy is carried out by convection, a fluid circulation driven by temperature gradients in the presence of gravity, rather than by radiation. The energy generated in the Sun's core takes a million years to reach its surface. It is because of this process that the Sun's mass becomes lighter and lighter as time passes.

The Sun is 4.5 billion years old, and since its birth it has used up about half of the hydrogen in its core. It is estimated that the Sun will continue to radiate for another 5 billion years, until the hydrogen fuel is completely depleted. The Sun will then be forced into radical changes, and will result in total destruction of the planets through a process called a planetary nebula. Planetary nebulae are shells of gas thrown out by stars, at the end of their lives. However, long before this crisis would occur, NASA plans to have humanity already arranged to live somewhere else besides Earth.

The Sun's diameter is 1,390,000 km.
The Sun's mass is 1.989e30 kg.
The Suns Temperature is 5800 K at the surface.
The Suns Temperature 15,600,000 K at the core.

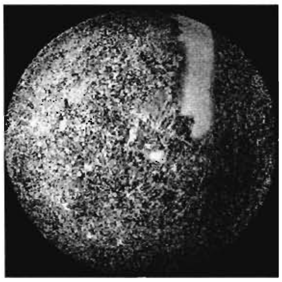


Lesson 3
Mercury and Venus

Key Terms
Green House Effect
Magellan
Mariner 1 & 2
Mariner 5
Mariner 10
Mercury
Venera 9
Venus

Lesson material

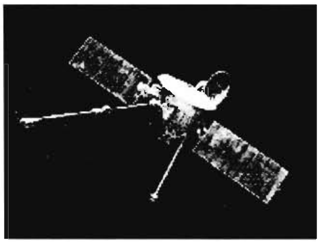
Mercury



Mercury is the closest planet to the Sun, and is the eighth largest in our solar system. It takes Mercury 88 days to complete its orbit around the sun once, and 59 days to complete a whole rotation around its axis. It is fairly close to Earth, so Mercury can sometimes be seen by the naked eye. Mercury's lack of atmosphere causes the greatest temperature variation of any planets, with temperatures on the Sun's side reaching 700 K, and on the dark side falling to 90 K.

Mercury's Orbit is 57,910,000 km from Sun.
Mercury's Diameter is 4,880 km
Mercury's Mass is 3.30e23 kg

Mariner 10

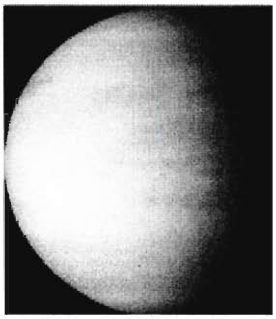


As of 2003 only one spacecraft had visited Mercury. This spacecraft was Mariner 10; it was the seventh successful launch in the Mariner series, the first ever spacecraft to use the gravitational pull of one planet (Venus) to reach another, and the first spacecraft mission to visit two planets.

Mariner 10 was launched on November 3 1973; however it did not reach Venus until February 5 1974, and on March 29 1974 the spacecraft crossed Mercury's orbit, 146 days after launch. The spacecraft revisited the planet twice more since the original flyby, and was able to map almost 45% of the Mercury's surface.

Venus

Venus is the second planet from the sun, and the sixth largest in our solar system. Besides the Sun and the Moon, Venus is the second brightest object in the sky. In comparison to Earth, Venus is the closest in size and gravitational pull of all the planets

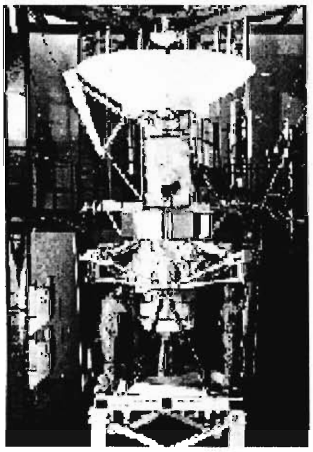


from Earth's vantage point. It takes Venus about 255 days to orbit the Sun, an d about 243 days to complete one rotation around its axis. Venus' thick atmosphere is composed of carbon dioxide, nitrogen, and clouds of sulfuric acid. On the surface the atmospheric pressure is about 90 times greater than that of Earth's. Due to the planet's this thick atmosphere, Venus can reach temperatures greater than that of Mercury, despite the fact that it is twice as far from the sun. The atmosphere's ability to retain heat so well is described by a process called the greenhouse Effect.

In the greenhouse effect, a glass house is able to become and stay hotter inside it then its surroundings, by allowing ultraviolet and infrared light to get inside the structure but not out of it. The initially strong rays from the Sun, which create the heat, are weakened after passing the glass, and so they bounce around inside the structure. This principle also applies to the planets' atmospheres, which act like the glasshouse trapping in the sun's rays, and allowing for the heat to stay in the planet.

Venus' orbit is 108,200,000 km from Sun
Venus' diameter is 12,103.6 km.
Venus's mass is 4.869e24 kg.

Mariner 1 was the first spacecraft designed to visit Venus, however the mission was canceled shortly after the spacecraft veered off course. Mariner 2 was the first spacecraft to visit Venus, but not the last. Since Mariner 2's encounter with the planet in 1962, Venus has been revisited by more than 20 other spacecrafts. Mariner 2 did however return the first information regarding surface temperatures, pressures, and other improved estimates on the planet's characteristics. It also discovered Venus' cloud covered atmosphere composed of carbon dioxide. In 1967 Mariner 5 measured the Venusian magnetic fields, charged particles, and plasmas, as well as radio refractivity and UV emissions of the Venusian atmosphere. In 1975 the USSR's Venera 9 was the first space craft to land on the surface of another planet besides Earth; it returned pictures of Venus' surface. In 1978 the Pioneer Venus was able to produce the first high quality map of Venus's surface. The most recent encounter with Venus was made by the Magellan, which was launched in May of 1989. Magellan has mapped about 98% Venus' surface at better than 300 meter resolution. The spacecraft has also obtained a comprehensive gravity field map for 95 percent of the planet.

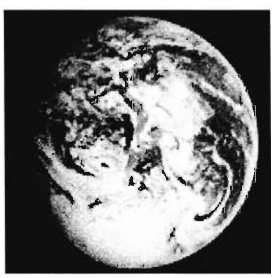


The Magellan Probe

Lesson 4
The Earth

Key Terms
Apollo 1-17
Gravitational Attraction
Highlands
Impact Theory
Luna 2 & 3
Maria
Organic
Ozone Layer
Photosynthesis
Plate Tectonics
Spreading
Subduction
Tides

Lesson Material



The Earth is the third planet from the Sun, and the middle sized planet in our solar system in terms of size. This means that four planets are larger, and four planets are smaller. It is the only planet in the solar system known to sustain life. It takes the Earth 365 days to complete one orbit around the Sun, and one day to complete a rotation around its axis. Earth is the densest planet in the solar system. Unlike Mercury and Venus, the Earth has one natural satellite, the Moon. The Moon is about 239,000 miles from Earth, and has a diameter of 260 miles. It is the only other body besides Earth in our solar system, where man has set foot.

Unlike the other planets, Earth contains organic matter; organic means carbon based. It is because of this that our planet is unique from all the others, and can sustain life on it. At first the Earth's surface temperature was too hot to sustain any life. However as years passed the ozone layer was created in our atmosphere, through a series of chemical reactions. The ozone layer then reduced the amount of ultraviolet radiation from the sun that reached Earth. This protection from the Sun's radiation allowed for the first steps in the evolution of life to occur. Water was able to exist, and in over many years, gasses and organic compounds formed the first signs of life.

Scientists theorize that substances that were not able to dissolve in water and other chemicals constituted the first living organisms. Over the course of 2 billion years, these organisms evolved into more complex multi cellular plants and animals. Photosynthesis was carried out by plants and produced oxygen, paving the way for the animals including humans' existence. Earth's atmosphere is currently composed of mostly nitrogen, 16% oxygen, 4% carbon dioxide and other gases. The Earth is the only planet where water can exist in liquid form on its surface, and 71% of Earth's surface is covered by water.

Another unique characteristic of planet Earth is its crust. Unlike any other planet we know of, the Earth's crust is divided into many solid plates which float around independently, resting on top of the hot mantle below; this is known as plate tectonics. Plate tectonics is characterized by the two main processes that of spreading and that of subduction. Spreading occurs when two plates move away from each other, and new crust is created from the upwelling magma from below the plates. Subduction occurs when two plates collide, and one plate is forced beneath the other, while the other one rises. Plate Tectonics are responsible for earthquakes, and the formation of mountains.

Earth's orbit is 149,600,000 km from Sun.
Earth's diameter is 12,756.3 km.
Earth's mass is 5.972e24 kg

The Moon

The Moon is the second brightest object in the sky after the Sun. It takes the Moon one month to complete one orbit around the Earth. As the Moon orbits the Earth, we see the Moon's visibility change from partially visible, to fully visible, then back to partially visible. The Moons illumination is created from the direct reflection of sunlight on the Moon; as the angles between the Sun, the Earth, and the Moon change, so does the Sun's reflection on the Moon, making it illuminate in the sky in different patterns.

The gravitational forces between the Earth and the Moon create some interesting effects; the tides are one of them. Since the Moon's gravitational attraction is stronger on the side of the Earth nearest to the Moon, high tides are seen during this phase of the Moon's orbit.

There are three main theories of the origin of the moon: it was formed during the same time as Earth from a dust cloud, it was a passing object captured by Earth's gravity, and it was a piece of Earth blasted loosely after a massive collision. However, the most accepted one is the impact theory of the creation of the moon. Although scientists are not positive about this theory, it is the basis for a fairly wide consensus that developed after the Apollo missions. The impact theory states that the Moon was created from the collision between Earth and another planet having approximately the same size as Mars. After the impact, the debris coalesced and created the Moon. Although the Moon has no atmosphere, water ice can be found in its north and south poles. The Moon also has two types of terrains on it, the old highlands, and the relatively young Maria. The Maria constitutes 16% of the moon, they are smooth terrains, and were created by huge impact craters that were flooded by molten lava.

In 1959, the USSR was the first country to send a spacecraft to the moon, that spacecraft was called the Luna 2. That same year the Luna 3 returned the first photos of the far side of the moon. FAR SIDE OF MOON, WHY WE CANT SEE

In the late 1960's NASA began its series of missions known as the Apollo program. The Apollo program had a mission to put men on the Moon and return them safely back to Earth. This was a three man mission, two astronauts would land, and one would orbit the Moon and rendezvous with the lander. However the USA did not have powerful enough rockets to launch such a large spacecraft, and as a result introduced Mercury, a one manned capsule program. Later on NASA introduced a two man capsule program called Gemini, which was carried out to give NASA a way to experiment with operations in space and to train astronauts. Meanwhile the three man Apollo spacecraft and its powerful Saturn 5 booster were created for transit to lunar orbit. Finally Apollo 11 took a Lunar launching module and descended to the Moon's surface for the first time, seven years after the first Mercury Program, where man orbited the planet Earth.

The Apollo Missions

The Apollo missions consisted of a command module (CM), and a lunar excursion module (LEM). Upon entering the Moon's orbit, the two modules would separate; one crew member would stay in the CM orbiting the Moon, while the other two astronauts would use the LRM to land on the Moon's surface. After completing their tasks on the moon, the two astronauts from the LEM would return to the CM and then return to Earth, leaving behind the LEM.

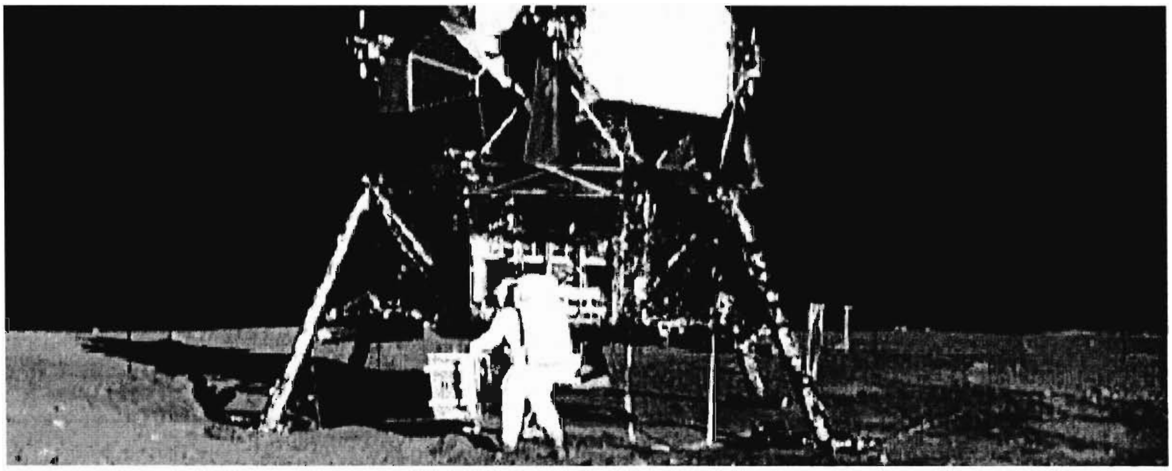
The Apollo 1-7 series were used for testing the Apollo modules in the Earth's atmosphere. Unfortunately the Apollo 1 and its three man crew were tragically lost in a fire during a pre launch test. The tragedy demonstrated to NASA that in a pure oxygen atmosphere things that would not burn up in the air, like wire insulator, could explode into flames and throw off a toxic smoke. On Earth systems that would have allowed astronauts to open the door in space, were not able to operate from the inside against gravity and air pressure. By the time support crew could open the CM from the outside, it was too late for the astronauts. They died trying to open that door each in his assigned position doing his duty as he was supposed to do it. The crew did not fail, but rather the engineers had failed them, and were heartbroken with grief and regret. Almost a year later the capsule was redesigned, and the atmosphere was shifted from pure oxygen to something more like air, but oxygen enriched.

Apollo 8 was the first spacecraft to orbit the moon; it was also the first manned spacecraft to leave Earth's gravity. The mission's goal was to test the Apollo's command module system; it was a success. The Apollo 10 was the second spacecraft to orbit the Moon, its mission was to prepare for Apollo 11's landing on the moon.

On July 20th 1969, the Apollo 11 landed on the lunar surface. This was the first mission in which humans walked on the surface of the moon. Commander Neil A. Armstrong, and pilot Edwin E. "Buzz" Aldrin Jr. were the first to step foot on

The Command Module of Apollo 11

the Moon's Mare Tranquilitatis. While on the Moon, the two astronauts setup scientific experiments, took photographs, and collected lunar samples. The Apollo 11 left the Moon on July 21 of the same year, and returned to Earth three days later. On November of that same year, the Apollo 12 performed a similar mission; commander Charles P. Conrad, and pilot Alan L. Bean were the second pair of astronauts to walk on the Moon's surface.


Astronaut Armstrong preparing the Apollo 11's Lunar Module for liftoff.

On April 11 1970, Apollo 13 was supposed to be the third space mission to send humans to the surface of the Moon. When an oxygen tank exploded however, the result was damage to the spacecraft's system, and the mission had to be aborted before a lunar landing even took place. The lunar Lander's oxygen and power supplies were used to save the crew on the trip back to Earth. The crew was almost lost during reentry, but made it home alive. Apollo 14-17 all performed similar missions as the previous ones; they all were successful. On December 11 1972 Commander Eugene A. Cernan and LM pilot Harrison H. Schmitt, from Apollo 17, were the last humans from the Apollo missions to walk on the moon.

The other planned missions were canceled to save money needed to build the "space transportation system" or reusable shuttle, which was to be the space truck needed to construct the space station. NASA was not authorized to build a space station at the time, but gambled that it would be given that mission eventually if it had the means, and so wanted to be prepared for it (The Reagan administration later on approved the space station mission).

Had this not been done, the US manned space program would have been over after the end of the Apollo missions. Manned missions cost 10-20 times what unmanned missions do, and the budget NASA was given by the Nixon administration would not have allowed NASA to continue to send men into space at all. The astronauts would have all had to been laid off and robotic probes would have to be sent into space instead. So, the moon missions stopped early, and the last Apollo capsule was used up in a publicity stunt involving its linkup with a Russian Soyez spacecraft, in which a crew member was exchanged; the event was practice for what a future rescue mission would involve. The Russians had a space station and were more active in manned space then the US at the time. NASA wanted one too, so as to study the effects of long term space missions of six months or more on the human body and mind.

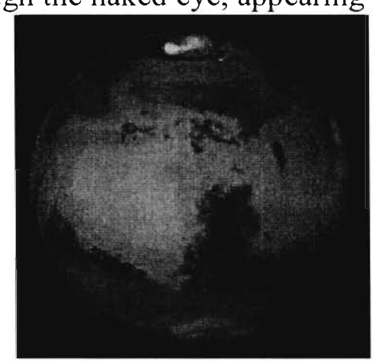
Lesson 5
Mars

Key Terms
Deimos
Inorganic
Mariner 3-4
Mariner 6-9
Mars
Mars 2 & 3
Mars Pathfinder
Phobos
Rover
Sojourner
Viking 1 & 2

Lesson Material

Mars

Mars is the fourth planet from the sun, and the sixth largest in our solar system, it is also the closest planet to Earth. Mars can be observed through the naked eye, appearing as a very bright red star. It has a diameter of almost half that of Earth, and a gravitational pull 38% that of the Earth. It takes Mars 686.97 days to complete an orbit around the Sun, and it completes one rotation around its axis in approximately one day and 37 minutes. The planet's temperature ranges from -220F to 60F. Its thin atmosphere is made up of 95.3% carbon dioxide, 2.7% nitrogen, 1.6% argon, and the rest of various traces of other gasses. Unlike some of the other planets which are made up of gas, Mars has a diverse topography, which includes volcanoes, canyons, dry riverbeds, and extensive seas of sand. Mars' soil is made up of magnesium, aluminum, calcium, and sulfur. Since this is an inorganic makeup (no carbon), chances of Mars sustaining native life form were considered non-existent based on the findings of the Viking Missions.



Mars has a large polar ice cap made up of water ice, and its atmosphere is saturated with water ice clouds. The amount of water however is very small, and if it were all precipitated from the atmosphere, it would only be 4/10,000 of an inch deep. The planet also has two natural satellites: Deimos, which is 7 miles wide, and Phobes, which is 14 miles wide.

Mars' orbit is 227,940,000 km from Sun
Mars' diameter is 6,794 km.
Mars' mass is 6.4219e23 kg.

Mariner 3,4,6,7,8,9

Mariner 3 was launched on November 5th 1964 to gather information on Mars. However when Mariner 3's protective shroud failed to eject, it was unable to collect the Sun's energy for power from its solar panels, and the probe soon failed when the batteries wore out. Mariner 4 the sister probe to Mariner 3, reached Mars in 1965. The spacecraft returned the first close-up images of the Martian surface and discovered Mars' cratered topography, and an atmosphere that was much thinner then previously believed.

Mariner 6 & 7 were dual spacecraft missions to Mars. The primary objectives of the missions were to study the surface and atmosphere of Mars during close flybys for two main reasons. The first reason was to establish a basis for future investigations, especially those relevant to the search of extraterrestrial life. The second, to demonstrate and develop technologies for future Mars missions and other long-duration missions relatively far from the Sun compared to Earth. Equipped with a wide and narrow angle television camera, an infrared spectroscope, an infrared radiometer, and an ultraviolet spectroscope, Mariner 6 & 7 the spacecrafts were oriented only to Mars data acquisition. The spacecrafts yielded some surprising results. Images showed that the surface of Mars had some contrasts to the results from Mariner 4. It was also discovered that the south polar cap was composed predominantly of Carbon Dioxide, and radio science was able to refine new estimates of Mars' mass, radius, and shape.

The Mariner 8 was supposed to be the first spacecraft to orbit the red planet, and to map 70% of the Martian surface. However shortly after its launch, the probe began to tumble out of control. Three weeks later on May 5th 1971, Mariner 9 was launched to incorporate Mariners 8's mission along with its own of studying the temporal changes in the Martian atmosphere and Martian surface. The mission resulted with a global mapping of Mars' surface, which revealed the first detailed views of the Martian volcanoes, canyons, and the polar caps, and the two moons, Phobos, and Deimos. Mariner 9 also provided information on global dust storms, the triaxial figure of Mars, the rugged gravitational field, as well as evidence for surface Aeolian activity.

Mars 2 & 3

The Mars 2 & 3 missions of 1971 consisted of identical spacecrafts, each with an orbiter module, and a lander module. The scientific objectives of the Mars 2 were to image the Martian surface and clouds, determine the planet's temperatures, study the topography and physical properties of the surface, measure atmospheric properties and solar winds, and act as a communication relay to send information to Earth from the Mars 2 lander. Likewise the primary objectives for the Mars 3 orbiter were to study the topography and physical properties of Mars' surface, to measure properties of the atmosphere, to monitor solar radiation, solar wind and interplanetary and Martian magnetic fields, and to act as a communications relay to send information to Earth from the Mars 3 lander. The Mars 2 was the first spacecraft to land on the Martian surface,

Viking 1 & 2

Like the Mars 2 & 3 spacecrafts, Viking 1 and Viking 2, consisted of both an orbiter and a lander. The primary mission objectives for the Viking spacecrafts were to obtain high resolution images of the Martian surface, to characterize the structure and composition of the atmosphere and surface, and to search for evidence of life. Viking 1, was launched on August 20 1975, and reached Mars' orbit on June 19 1976; the lander touched down at Chryse Planitia on July 20 1976. Viking 2 was launched on September 9 1975, and reached Mars' orbit on August 7 1976; the lander separated from its orbiter on September 3rd 1976 at Utopia Planitia.

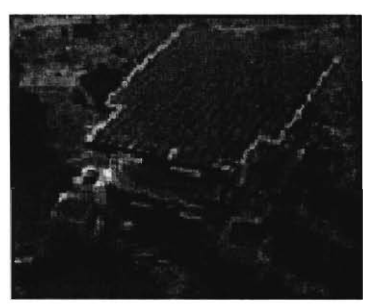
A view of the Martian terrain from Viking 1

The Viking 2 orbiter was terminated on July 25 1978 after 706 orbits, while the Viking 1 Orbiter was terminated on August 17 1980, after over 1400 orbits. After having transmitted images of the surface, sampling and analyzing the surface for compositions and signs of life, studying atmospheric composition and meteorology, and deploying seismometers the Viking Landers ended communications shortly after their orbiters did. On April 11, 1980 the Viking 2 Lander ended its communications, and on November 3, 1982 the Viking 1 Lander completed its mission.

The Viking missions have provided some of the most complete views of Mars to date. Through the Viking Orbiters images, Volcanoes, lava plains, immense canyons, cratered areas, wind formed features, and evidence of surface water have been discovered. The Vikings revealed that the planet is divided into two main regions: northern low plains, and southern cratered highlands. The surface material at both the landing sites was characterized as iron-rich clay, but the biological experiment showed no evidence of life at either landing site.

Mars Pathfinder

20 years after the last contact with Mars, NASA launched the Mars Pathfinder on December 4th 1996. The mission consisted of a stationary lander and a surface rover called Sojourner. The objective of the mission was to demonstrate whether or not low-cost landings and explorations could be achieved on the Marian surface. The spacecraft entered the Martina atmosphere without orbiting the planet; it used the aid of parachutes, rockets, and airbags in order to land on the red planet. On July 4th 1997, the mission objective was met. The Pathfinder's scientific objectives included atmospheric entry science, and long-range and close-up surface imaging. Its general goal was to further explore the Martian environment.



The Sojourner

The Mars Expedition Rovers

On June 10 and July 7, 2003, NASA launched its twin robot geologists towards Mars, in search of answering questions about the history of water on the red planet. Some other mission goals included, characterizing a wide range of rocks that could hold clues to past water activity. On January 4 and January 25, 2004, the two rovers landed on opposite sides of the planet, in the same crude manner that Pathfinder did. The first landing site was at Gusev Crater, a possible former lake in a giant impact crater. The second landing was at Meridiani Planum, a site that suggests Mars had a wet past, due to the mineral deposits left behind.

Upon landing, the rovers leave their petal structure behind, and drive off to begin their exploration. Using daily images from the rover, scientists will command the vehicles to go to rock and soil targets of interest, where they will be able to evaluate the composition and textures at microscopic scales. These rovers are so mobile, that in one Martian day they will have the ability to cover as much surface as the Sojourner did in its entire lifetime.

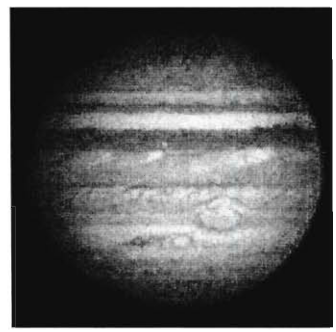
A model of the Mars Expedition Rover.

Lesson 6
Jupiter and Saturn

Key Terms
Aurora
Jupiter
Saturn
Pioneer 10 & 11
Voyager 1 & 2

Lesson Material

Jupiter

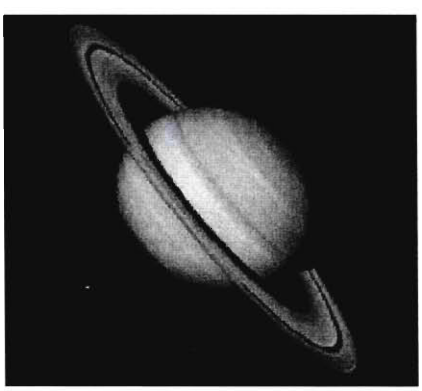


Jupiter is the fifth planet from the Sun, and the largest in our solar system. It takes 11.82 years for Jupiter to orbit the Sun, and 9 hours and 50 minutes to complete a rotation around its axis. Unlike the other planets, Jupiter rotates around its axis counter clockwise. Its gravity is 2.64 times that of the Earth's. The planet is composed of 88% hydrogen and 11% helium gas; it contains 70% of all the matter that make up the planets. Many locations on Jupiter have temperatures that could sustain life, if the planet were not made up of gas. In addition powerful storms like the Red Spot, make life on Jupiter impossible. Jupiter has 16 natural satellites; Lo, the largest moon in the solar system, exhibits more volcanic activity than any other moon we know of.

Jupiter's orbit is 778,330,000 km from Sun.
Jupiter's diameter is 142,984 km.
Jupiter's mass is 1.900e27 kg.

Saturn

Saturn is the sixth planet from the Sun, and is the second largest in our solar system. Its gravity is 1.14 times stronger than the Earth's, and like Jupiter it is made up of mostly hydrogen and helium. However, Saturn's core is believed to be composed of water, methane, and ammonia. Saturn's most obvious characteristic is the millions of thin rings that circle around the planets orbital plane. The planet also has more natural satellites than any other planet in the solar system, with a count within 21-23. Titan, one of Saturn's moons, has an organic atmosphere made up off nitrogen and hydrogen cyanide. This is the only place in the solar system where hydrogen cyanide has been found.



Saturn’s orbit is 1,429,400,000 km from Sun.
Saturn’s diameter is120,536 km.
Saturn’s mass is 5.68e26 kg

The Pioneer 10 was the first spacecraft to visit Jupiter in 1973. In 1974 the Pioneer 11 was the second; it went on to become the first probe to visit Saturn 5 years later in 1979. The Pioneers were designed to test the ability of a spacecraft to survive passing through The Main Asteroid Belt, and Jupiter’s magnetosphere. While the first part was easy, the ions trapped in Jupiter’s magnetic field almost fried the spacecraft; this mission gave crucial insight for the success of the future Voyager missions. The two spacecrafts are now heading into interstellar space. As the first two spacecrafts leave our solar system, a graphic message is carried in a 6-9 inch gold plaque on the spacecrafts main frame.

The Voyager 1 was launched on September 5 1977, reached Jupiter on March 5 1979, and then Saturn on November 13 1980. The Voyager 2 was launched August 20 1977, reached Jupiter on August 7 1977, and then Saturn on August 26 1981. These two probes greatly increased our knowledge of these two planets. The probes discovered that Jupiter had complicated atmospheric dynamics, lighting, and aurora, a glow in a planet's ionosphere caused by the interaction between the planet's magnetic field and charged particles from the Sun. The probes also discovered Jupiter’s few rings, and the intense sulfuric volcanic activities in Io. When the probes reached Saturn, they discovered over 1000 ringlets, and 7 natural satellites.

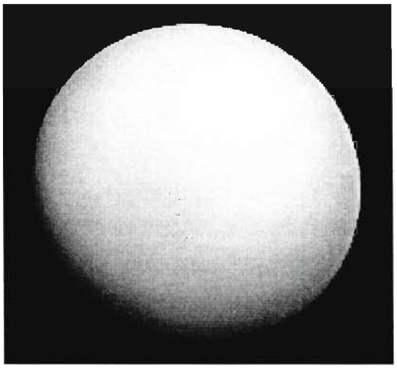

The Voyager

Lesson 7
The Outer Planets

Key Terms
Charon
Neptune
Pluto
Uranus
Voyager 2

Lesson Material

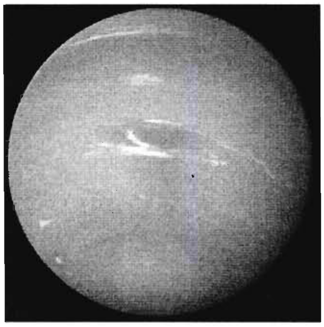
Uranus



Uranus is the seventh planet from the Sun. Uranus' force of gravity is 1.04 times stronger than that of Earth. Like Jupiter and Saturn, the planet is made up mostly of hydrogen and helium. A unique characteristic of this planet is that it rotates on an axis that lies within it orbital plane. As a result, Uranus appears to "roll" along its orbit from "above." No other planet exhibits this type of rotation. Uranus also has a set of 10 rings, however unlike Saturn, they don't lie on the planet's orbital plane, but rather the planet's north and south poles. Uranus has five moons.

Uranus' orbit is 2,870,990,000 km from Sun.
Uranus' diameter is 1,118 km.
Uranus' mass is 8.683e25 kg.

Neptune



Neptune is the eighth planet from the Sun, and is the fourth largest planet in our solar system. It takes Neptune 165 years to orbit the Sun, and 5.8 hours to complete one rotation around its axis. Because of Neptune's highly eccentric orbit, it is sometimes the farthest planet from the Sun.

Neptune's orbit is 4,504,000,000 km from Sun.
Neptune's diameter is 49,532 km.
Neptune's mass is 1.0247e26 kg

Pluto

Pluto is the ninth planet from the Sun, and is also the smallest planet in the solar system. From Pluto, the Sun only appears as a bright star. Pluto is the only planet that does not lie in the same plane as the others. The planet is composed of half rock, and half methane frost, it has one moon, Charon.

Pluto's orbit is 5,913,520,000 km from the Sun.
Pluto's diameter is 2274 km.
Pluto's mass is 1.27e22 kg

The Voyager 2 continued its path from Saturn to visit Uranus on January 24 1986, and then Neptune on August 25 1989. The spacecraft was able to obtain 8,000 pictures of Uranus and its satellites, and about 10,000 images of Neptune and its satellites. As of present time, no spacecraft has visited Pluto.

Lesson 8
The Different Space Organizations

Key Terms

Lesson Materials

Over the last 40 years there have been several main organizations devoting their efforts to the exploration of space, a few of them include: NASA, RSA, CNSA, JAXA, and ESA. Although these organizations differ in some ways, in 1998 a group of 15 countries put their efforts together to begin the employment of a massive manned facility in outer space known as the International Space Station (ISS). The project will be the sum of the latest technologies developed by each of the participating countries, and it is not expected to be completed until 2008. The ISS is planned to be 356 feet across and 290 feet long. Almost an acre of solar panels will provide electrical power to six state of the art laboratories.

NASA

On October 1 1958, the National Aeronautics and Space Program (NASA) was started as a result of the President Eisenhower's and congress' pressures for improved national defense. After World War II the United States and Russia were engaged in a Cold War, it was during this period of time that space exploration emerged, and the space race began.

NASA quickly inherited the National Advisory Committee for Aeronautics (NACA), and other government organizations and almost immediately began working on human space travel. In the late 60's to mid 70's NASA focused on their Apollo missions which sent humans to the face of the moon. In 1981 human spaceflights resumed with the space shuttle program, which continues today in order to help build the International Space Station. NASA also continues to perform research on cutting edge aeronautics, astronomical discoveries about our universe, satellite communications, and more. In 1990 NASA launched the Hubble Space Telescope into Earth's orbit. This powerful telescope had the capabilities of focusing into a dime sized object from 200km away but has had to be repaired and serviced in space a few times. NASA has to decide whether or not to do so again or to close it.

RSA

Before the Russian Space Administration (RSA) even existed, the Soviet Space Program had left a renowned name for itself. The Soviet Space Program's ideology believed that man's utility in space was enormous and should be exploited. On April 12, 1961, the U.S.S.R performed the first manned space flight. After the Soviet's N1 failed to send the first cosmonauts, the Russian equivalent to astronauts, to the Moon, the soviets focused on unmanned space travel. The Soviets quickly responded to the "space race" after the US' first lunar walk, by sending unmanned probes to the moon, and Mars. They were also the first to send a spacecraft to Venus.

Russia became very interested in space and rockets and prior to World War II and had a bureau that was making great strides. However, the Germans invited him to Berlin and later convinced Stalin that he was a turncoat and traitor. Stalin had him executed and sent most of those he trained to the Gulags. Among the few survivors was Korolev, who after the war was sent to the German base of Penemube to gather up all the equipment and trained personnel that he could use to start over and rebuild the soviet space organization as an NPO (National Production Organization). Euergiaa, Werhner, Voy Braun, and about 40 other senior scientists and engineers from Pareheunde escaped and traveled west, so as to be captured by the Americans and British, who were looking for them. Kovolev and Van Braun would later face off in the USA – USSR space race, both starting from what was learned at Penemunde, building V1 and V2 terror rockets for Hitler.

Chief designer Kovolev's identity was a state secret, but NPO's Eurgia rapidly emerged as the world leader in space after the Russians landed both the first satellite, and the first manned orbital mission. Kovolev designed a more powerful rocket than the US had, because he was aware of what the first Soviet atomic devices would weigh. This Soviet advantage in "throw weight" would plaque the early efforts of the Americans who had to worry about weight and miniaturization, while the Soviets could build big and bulky things weighing a ton or more and get them into the Earth's orbit. Further, the USA's Vangrord team (all American navy project) while

CNSA

The China National Space Administration (CNSA) was born in 1956. China started studying the Earth's upper atmosphere using rockets and balloons in the late 1960's and early 1970's. The CNSA's goals are

> "to explore outer space, and learn more about the cosmos and the Earth; to utilize outer space for peaceful purposes, promote mankind's civilization and social progress, and benefit the whole of mankind; and to meet the growing demands of economic construction, national security, science and technology development and social progress, protect China's national interests and build up the comprehensive national strength."

China has had some success with sending humans to space, as was evident from their Project 921, in which astronauts are training for an orbital mission it the Shenzhou, a three man capsule. Slowly taking their time and buying equipment and training from Russia, in order to keep their costs low, China has proved to have the adequate technology to send man to space. Although the CNSA is at very frugal state, an economic boom in China could result in a superior growth for China's space program.

JAXA

During the dawn of space aeronautics, three organizations were developed in Japan to explore the cosmos: The Institute of Space and Astronautical Science (ISAS), The National Aerospace Laboratory of Japan (NAL), and The National Space Development Agency of Japan (NASDA). While ISAS was devoted to space and planetary research, NAL was focusing on research and development of next-generation aviation, and NASDA was responsible for the development of large launch vehicles and space stations. On October 1, 1993, the three groups merged into one independent administrative institution known as the Japan Aerospace Exploration Agency (JAXA). The goal of JAXA was to allow a continuous and systematic approach to space exploration, from basic research to development and practical application.

ISAS history began in 1955 with the "pencil" rocket experiment at the University of Tokyo, 9 years later the organization was officially founded at the same university. ISAS was responsible for Japan's first artificial satellite OHSUMI, which was launched into orbit by an L-4S rocket. Since then the ISAS' performed missions that were favored by both the space science staff, which researched the mysteries of space, and the engineering staff, which tried to comply with the needs of space science.

NAL was established in July on 1955. Since their establishment NAL has researched aircrafts, rockets, and other aeronautical transportation systems. NASDA was established on October 1, 1969 under Japan's National Space Development Agency Law, to act as the center for space development, and to promote the peaceful use of space. Through its history NASDA has developed satellites, launching vehicles, facilities and equipments, has performed space experiments including the space station, and has launched and tracked their own spacecrafts.

ESA

The European Space Agency (EAS), is constituted by 15 member states, Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom. Greece and Luxembourg are expected to become members of ESA in 2004. The organization's mission is "to shape the development of Europe's space capability and ensure that investment in space continues to deliver benefits to the citizens of Europe." The agency focuses on gathering information on the Earth, the space environment, the solar system, and the Universe. ESA also focuses on developing satellite based technologies and services that help promote European industries. The ESA's headquarters are in Paris, France, however four other centers are scattered throughout Europe.

Lesson 9
Manned vs. Unmanned Space Travel

Key Terms

Lesson Materials

Scientists have all agreed that the Earth will not exist forever, they also agree on the fact that the Earth is only a tiny "blue marble" in the cosmos. The notion to preserve human kind by rebuilding a civilization in outer space before a cosmic catastrophe occurs has been the motive for many space organizations.

Over the last three and a half decades the USA's NASA has been heavily devoted to sending humans to outer space. More recently there has been an obsession with getting back to the Moon, Mars, and the stars. Although NASA does partake in unmanned missions, the organization favors those that can be viewed as forerunners for later manned missions. An example of this was Viking I, the first spacecraft to land softly on Mars' surface.

ESA is on the other side of the spectrum on the manned vs. unmanned policy. ESA's reasoning for going into space is for the sole purposes to collect information, and to provide some other valuable commodity or service. They believe in the concept of expending as few resources to get out of space, and to retrieve what ever is desired. The ESA organization in contrast to NASA is very intolerant of cost over runs, even a 10% increase would result a project to be re-authorized. This frugal mentality is what has driven the ESA away from manned missions.

The rest of the space agencies are more conflicted on a man vs. unmanned commitment. Russia is the world's leader when it comes to the amount of time humans have spent on space stations, yet their performance with unmanned missions also continued to succeed. When the Russians failed to send the first humans to the moon, they came back with an unmanned mission to the moon, then mars, and then Venus. The Russians have demonstrated how successful and useful unmanned space mission can be achieved at a lower cost than manned missions. However evidence has revealed that if Russia had the available funds it would have invested it in manned technology.

Both the topics of manned and unmanned missions have their pros and cons. NASA believes that a manned space program is highly necessary for a few different reasons. The first reason is to teach humans how to perform various tasks so that they can be ready for when a permanent manned space station is established. Another advantage to having humans in space is that human are more adoptable to different circumstances then machines are. By providing a human's intelligent thinking to various missions, the results may be more productive. It has been found that long term exposure to a zero gravity environment is harmful to the human form, since very little effort is needed to move when weightless. This weightlessness effect also causes bones to lose their vital calcium, and in time bones and muscles slowly weaken. This brings another reason for why NASA favors the manned missions so much: in order to study how humans react to long term weightlessness and to learn how to counteract the negative effects caused by it. Without ways to deal with zero gravity, manned travel will be impossible.

Although NASA's main area of research is outside the Earth's atmosphere, the area is not capable of supporting life without it being altered. The two options of using machines rather than humans to do research, or creating life support systems to allow humans to do research, has become a critical issue on which of the two NASA should allocate its funds to. Although NASA representatives claim that manned missions offer flexibility and the ability to deal with unexpected situations, the price tag for such missions is twenty times greater than that of unmanned ones. Another argument that favors unmanned space travel is the fact that manned missions have not yielded many scientific discoveries, since shuttles cannot travel outside of Earth's orbit. On the other hand unmanned probes have been able to reach the outer reaches of our solar system, and have retrieved a plethora of useful data. Another problem with the manned program is the risk involved in loosing human lives. While unmanned missions can avoid the loss of life, manned missions can result in problems causing fatalities, like in the case of the Challenger in 1986, and the Apollo 1 in 1969. Because of this risk of losing human lives manned systems must be 99% reliable, while unmanned systems may only be 90% reliable for their missions to still be acceptable. This 9% increase which involves extra precautions, and backup systems, typically doubles the cost of a mission. It is also true that manned flights often complicate missions by switching the focus from science to life support. While currently NASA spends 80% of their budget on manned space travel and only 20% on unmanned. If a slight change was made to incorporate a 70% / 30% division many believe that more science would be acquired for the cost.

Appendix E – The S-STS curriculum

Introduction:

This is the S-STS curriculum format based on "The Sun, the Earth and NASA." It will be structured in a 10 lesson format that will span over 31/2 weeks (3 lessons a week). The lesson format will be based on an S-STS curriculum format which will:
Introduce a social issue that will encompass the whole curricula.
Learn the abstract concepts through lessons geared toward presenting themes related to the social issue.
Conclude with an activity that will help reinforce the abstract concepts and also make a decision about the social issue.

Lesson 1:
Unmanned Vs. Manned Space Travel
Lesson 2:
ISATP and NASA
Lesson 3:
Viking Missions
Lesson 4:
Mariner Missions
Lesson 5:
Voyager Missions
Lesson 6:
The Hubble Space Telescope
Lesson 7:
Apollo Missions
Lesson 8:
Rover Missions
Lesson 9:
Debate Preperation
Lesson 10:
Debate and Conclusion

Lesson 1
Unmanned Vs. Manned Space Travel

Lesson Material

The Solar System and space have always been one of man's biggest interests. Despite the fascination of space there is still a lot of information that is unknown about the areas beyond the Earth. Since the solar system is a topic in science with such little information there are many scientists who question the paradigms set by the scientific community about space. In a situation such as the state the scientific community views space, it is common to have many paradigm changes. One example of paradigm change in the area of space can be seen when the scientific community adopted the heliocentric model of the universe over the geocentric model. Nicholas Copernicus proposed the heliocentric theory of the solar system after he died. Then Galileo also proposed the heliocentric theory to the Catholic church, but was imprisoned for it. Later many scientists all starting agreeing that the solar system was heliocentric until the church also adopted the theory. After this time scientist who studied space and the solar system are encouraged to question paradigms set by the scientific community. This led to a much more rapid approach to discovering new information about the solar system. Later on in the 20th Century many countries in the world had space programs that were sending rockets up into space to try to learn more information about it. This led to the creation of NASA, USA's primary organization for space exploration.

The National Aeronautics and Space Administration (NASA) was created on October 1, 1958. Its continuing purpose is to advance human space flight and its space applications. NASA was formed during the Space race of the 1960's. The Russians had sent the first unmanned object into space, Sputnik. The United States of America was shocked. Lack of confidence in the military rocket programs led NASA to be formed by inheriting the earlier National Advisory Committee for Aeronautics (NACA), and almost immediately began working on options for human space flight. NASA's first high profile program was Project Mercury, an effort to learn if humans could survive in space, followed by Project Gemini, which built upon Mercury's successes and used spacecraft built for two astronauts. NASA's human space flight efforts then extended to the Moon with Project Apollo, culminating in 1969 when the Apollo 11 mission first put humans on the lunar surface.

Since its inception, NASA has been fully focused on manned space missions. The only missions that are endorsed are ones that could further the ability to be a stepping-stone to the stars for man. They have carefully chosen their missions to be a specific type of mission. One that furthers their understanding of mans future place in space.

After President Bush's speech on "A renewed Spirit of Space Travel" (see appendix A) many people have raised the question: "which way of space exploration was more beneficial and cost effective to the United States?". As of right now NASA spends 95% of their budget on manned missions and 5% on unmanned missions. Looking back on NASA's track record of manned and unmanned missions, the unmanned missions have been considered more successful and much more cost effective. NASA still spends much more money on the manned programs due to the mindset of the organization (see appendix B). On the other hand, NASA group of scientist that run the unmanned missions have taken their own view on space exploration based around unmanned space exploration (see appendix C). Both of these plans have their advantages and disadvantages. The problem is that NASA is always under a budget and they are always in a race against time to learn what they can about the solar system. Currently there have been questions about where to spend the money that is allotted for the NASA space program. Throughout this curriculum the question of where NASA should invest their money should be in the student's thoughts at all times.

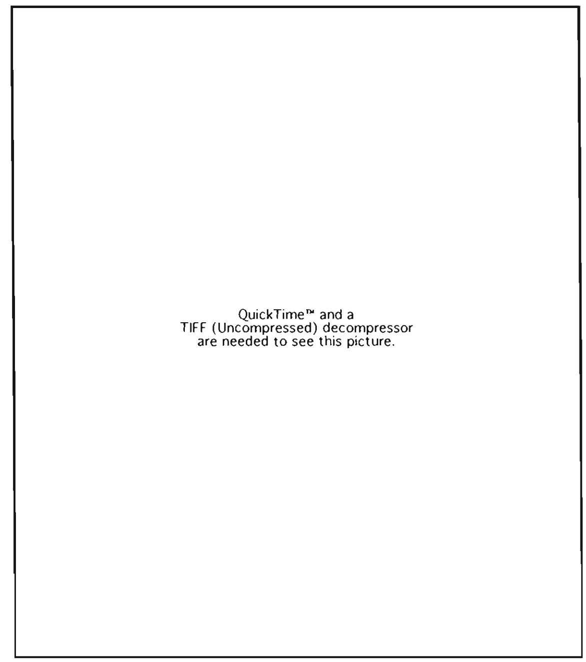
The way this curriculum is formatted at the end of the lesson plan each student will make their own decision on which plan they think is better. The next seven lessons will each introduce a different mission to explore the solar system and what we learned on those missions. At the end of the unit there will be a debate between people who believe in manned space travel and people who believe in unmanned space exploration.

Lesson 2
IASTP

Lesson Material

The next seven lessons are going to look at the history of USA's involvement in the space exploration. It will go through many missions that were conducted by different American space organizations. The first two missions we are going to look at helped people learn many things about the Earth and the sun.

The first set of missions we are going to talk about were run by the InterAgency Solar-Terrestrial Program (IASTP). The goal of the IASTP was to help answer questions on how the Sun transfers energy to the near-Earth space and atmospheric environment. The plan of the IASTP was to run a series of unmanned missions to help gain the information needed to answer the questions. Over the last 30 years IASTP has run many unmanned missions that have gather much information about the sun and the Earth. The US ran two missions in conjunction with the IASTP. These missions were the WIND and POLAR mission. The WIND mission was ran to collect information about the solar wind force. The WIND Satellite was launched by NASA on November 1, 1994 to study the interplanetary medium and the effects of changes and disturbances in it upon the magnetosphere. The POLAR sattelite, launched on February 24, 1996, marked NASA as completed placing into orbit all of its spacecraft contributions to the Inter Agency Solar Terrestrial Physics Program (IASTP). Polar became operational at the beginning of April and continues to provide new and unique data to the program. The purpose of the POLAR satellite was to gather information about the Earth's ionosphere (for more information about the ionosphere visit http://www.haarp.alaska.edu/haarp/ion1.html). These two missions helped evolve theories and facts about the Earth and Sun that are used today in many science books across the nation.



Many of the things learned about the sun came from the research done by the IASTP. The research done by the IASTP helped prove many interesting facts about the sun, the Earth and their relationship. Here are some facts about the sun and the Earth that were reinforced by the missions done by the IASTP:

The sun is one of more than 100 billion stars in our galaxy, it is the largest object in our solar system, and contains almost 99.8% of our solar system's mass. Having a size 110 times larger than that of earth, the Sun is composed of 70% hydrogen, 28% helium, and about 2% carbon, nitrogen, oxygen, and traces of other elements. The Sun's energy is produced through a process called nuclear fusion, where each second, about 700,000,000 tons of hydrogen are converted to about 695,000,000 tons of helium and 5,000,000 tons of energy in the form of gamma rays. This energy, then travels out toward the surface of the sun, where it is continuously absorbed and re-emitted at lower and lower temperatures, so that by the time it has reached the surface the energy has formed into visible light. For the last 20% of the energy's path to the surface, the energy is carried out by convection, a fluid circulation driven by temperature gradients in the presence of gravity, rather than by radiation.

The Sun's diameter is 1,390,000 km.

The Sun's mass is 1.989e30 kg.

The Suns Temperature is 5800 K at the surface.

The Suns Temperature 15,600,000 K at the core.

Earth

The Earth is the third planet from the Sun, and the median planet in our solar system in terms of size. This means that four planets are larger, and four planets are smaller. It is the only planet in the solar system known to sustain life. It takes the Earth 365 days to complete one orbit around the Sun, and one day to complete a rotation around its axis. Unlike Mercury and Venus, the Earth has a natural satellite, known as the moon. The moon is about 239,000 miles from Earth, and has a diameter of 260 miles. It is the only other body besides Earth in out solar system, where man has set foot.

Unlike the other planets, Earth contains organic matter; organic means carbon based. It is because of this that our planet is unique from all the others, and can sustain life on it. At first the Earth's surface temperature was too hot to sustain any life. However as years passed the ozone layer was created in our atmosphere, through a series of chemical reactions. The ozone layer then reduced the amounts of ultraviolet radiation from the sun that reached Earth. This protection from the Sun's radiation allowed for the first steps in the evolution of life to occur. Water was able to exist, and in over many years, gasses and organic compounds formed the first signs of life. Scientists theorize that substances that were not able to dissolve in water and other chemicals constituted the first living organisms. Over the course of 2 billion years, these organisms evolved into higher plants and animals. Photosynthesis created by plants produced oxygen, paving the way for animals including humans' existence. Earth's atmosphere is currently composed of mostly nitrogen, 16% oxygen, 4% carbon dioxide and other gases.

Earth's orbit is 149,600,000 km from Sun.

Earth's diameter is 12,756.3 km.

Earth's mass is 5.972e24 kg

Lesson 3
Viking Missions to Mars

Lesson Material

The next set of missions that we are going to look at is the Viking missions to Mars. These missions were all unmanned and were able to send back many pictures of Mars, which helped lead to some major discoveries for the planet. The main goals of the Viking missions were to obtain high-resolution images of the Martian surface, to characterize the structure and composition of the atmosphere and surface, and to search for evidence of life. NASA's Viking Project found a place in history when it became the first mission to land a spacecraft safely on the surface of another planet. Two identical spacecraft, each consisting of a lander and an orbiter, were built. Viking 1, was launched on August 20 1975, and reached Mars' orbit on June 19 1976; the lander touched down at Chryse Planitia on July 20 1976. Viking 2 was launched on September 9 1975, and reached Mars' orbit on August 7 1976; the lander separated from its orbiter on September 3rd 1976 at Utopia Planitia.
The Viking missions have provided some of the best views of Mars to date. Through the Viking Orbiters images, Volcanoes, lava plains, immense canyons, cratered areas, wind formed features, and evidence of surface water have been discovered. The Vikings revealed that the planet is divided into two main regions: northern low plains, and southern cratered highlands. The surface material at both the landing sites was characterized as iron-rich clay, but the biological experiment showed no evidence of life at either landing site.

The reason NASA accepted this Viking unmanned mission was because it would lead to current studies into Mars' surface and the possibility of a future manned mission. Already in place is a planned mission for humans to land on Mars by 2010. The EU is also looking into landing on mars, but fully automized. Manned missions are thought to be extremely dangerous, and cost ineffective. The average manned mission cost 10 times that of unmanned ones. Much information about Mars was learned through these missions. The pictures helped prove existing theories about the planet. Here is some of the information that the pictures helped solidify:

Mars

Mars is the fourth planet from the sun, and the sixth largest in our solar system, it is also the closest planet to Earth. Mars can be observed through the naked eye, appearing as a very bright red star. It has a diameter of almost half of earth, and a gravitational pull 38% that of the Earth. It takes Mars 686.97 days to complete an orbit around the Sun, and completes one rotation around its axis in approximately one day and 37 minutes. The planet's temperature ranges from -220F to 60F. Its thin atmosphere is made up of 95.3% carbon dioxide, 2.7% nitrogen, 1.6% argon, and the rest of various traces of other gasses. Unlike the other planets which are made up of gas, Mars has a diverse topography, which includes volcanoes, canyons, dry riverbeds, and extensive seas of sand. Mars' soil is made up of magnesium, aluminum, calcium, and sulfur. Since this is an inorganic makeup (no carbon), chances of Mars sustaining microscopic life are exceedingly small, but scientists are still looking for meteorites from Mars with proof of life from the planet.

Mars has a large polar ice cap made up of water ice, and its atmosphere is saturated with water ice clouds. The amount of water however is very small, and if it were all precipitated from the atmosphere, it would only be 4/10,000 of an inch deep. The planet also has two natural satellites: Deimos, which is 7 miles wide, and Phobes, which is 14 miles wide.

Mars' orbit is 227,940,000 km from Sun.
Mars' diameter is 6,794 km.
Mars' mass is 6.4219e23 kg.

Volcanoes, lava plains, huge canyons, cratered areas, wind-formed features, and evidence of surface water are apparent in the orbiter images. The planet appears to be divisible into two main regions, northern low plains and southern cratered highlands. Measured temperatures at the landing sites ranged from 150 to 250 Kelvin, with a variation over a given day of 35 to 50 Kelvin. Seasonal dust storms, pressure changes, and transport of atmospheric gases between the polar caps were observed. The biology experiment produced no evidence of life at either landing site, but if water is ever formed on Mars the search for fossils and microscopic organisms will begin again.

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Lessons 4
Mariner Missions to Venus

Lesson Material

The next set of missions that we are going to look are the Mariner Missions. Another set of space missions by NASA was the Mariner missions. They were designed to explore the lower orbit of Venus. All together there were 10 Mariner missions. The first Mariner mission was attempted in 1962 and was destroyed shortly after launch when vehicle veered off course.
Mariner TWO was launched on August 27th 1962. The Mariner 2 spacecraft was the second of a series of spacecraft used for planetary exploration in no landing mode and the first spacecraft to successfully encounter another planet. Mariner 2 was a backup for the Mariner 1 mission. The objective of the Mariner 2 mission was to fly by Venus and return data on the planet's atmosphere, magnetic field, charged particle environment, and mass.
Scientific discoveries made by Mariner 2 included a slow retrograde rotation rate for Venus, hot surface temperatures and high surface pressures, a predominantly carbon dioxide atmosphere, continuous cloud cover with a top altitude of about 60 km, and no detectable magnetic field. It was also shown that in interplanetary space the solar wind streams continuously and the cosmic dust density is much lower than the near-Earth region. (NASA.gov)
Mariner 3 was launched on November 5th 1964. Mariner 3 was a small solar-cell and battery-powered spacecraft created to make measurements in the vicinity of Mars and to obtain photographs of the planet's surface and transmit these to Earth. It was intended that the Mariner would Reach Mars after a 325-million mile journey in a little less than 8 months. A protective shield failed to eject after the spacecraft had passed through the atmosphere. None of the instrument sensors were uncovered, and the added weight prevented the spacecraft from attaining its prescribed Mars trajectory. Mariner was a failure.
Mariner 4-7 were launched in 1965, 1967, 1969, and another in 1969 respectively. Their missions were to photograph the lower surface areas of Mars and Venus. They all were successful in their missions of taking atmospheric readings and photographing the surface of either Mars or Venus.
Mariner 8 was launched in 1971 and malfunctioned shortly after launch. Mariner 9 was quickly launched in its place. Mariner 10 was the seventh successful launch in the Mariner series, the first spacecraft to use the gravitational pull of one planet (Venus) to reach another (Mercury), and the first spacecraft mission to visit two planets. Mariner 10 was the first (and as of 2003 the only) spacecraft to visit Mercury. The spacecraft flew by Mercury three times in a retrograde heliocentric orbit and returned images and data on the planet.
Venus

Venus is the second planet from the sun, and the sixth largest in our solar system. Besides the Sun and the Moon, Venus is the second brightest object in the sky. In comparison to Earth, Venus is the closest in size of all the planets, and gravitational pull. It takes Venus about 255 days to orbit the Sun, and about 243 days to complete one rotation around its axis. Venus' thick atmosphere is composed of carbon dioxide, nitrogen, and clouds of sulfuric acid. On its surface this atmosphere is about 90 times greater than that of Earth's. Due to the planet's this thick atmosphere, Venus can reach temperatures greater than that of Mercury, despite the fact that it is twice as far from the sun. The atmosphere's ability to retain heat so well is described by a process called the Green House Effect.

Venus' orbit is 108,200,000 km from Sun
Venus' diameter is 12,103.6 km.
Venus's mass is 4.869e24 kg.

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(Retrograde Heliocentric orbit)

Mariner 10 returned the first-ever close-up images of Venus and Mercury. The primary scientific objectives of the mission were to measure Mercury's environment, atmosphere, surface, and body characteristics and to make similar investigations of Venus. Secondary objectives were to perform experiments in the interplanetary medium and to obtain experience with a dual-planet gravity-assist mission.

Mercury

Mercury is the closest planet to the Sun, and is the eighth largest in our solar system. It t1akes Mercury 88 days to complete its orbit around the sun once, and 59 days, to complete a whole rotation around its axis. Because of its fairly close distance to Earth, Mercury can sometimes be seen by the naked eye. Because of Mercury's lack of atmosphere, it has the greatest temperature variation of any planets, with temperatures on the Sun's side reaching 700 K, and temperatures on the dark side falling to 90 K.

Mercury's Orbit is 57,910,000 km from Sun.
Mercury's Diameter is 4,880 km
Mercury's Mass is 3.30e23 kg

Total research, development, launch, and support costs for the Mariner series of spacecraft (Mariners 1 through 10) was approximately $554 million. (NASA.gov)

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(Versions of the Mariner Spacecraft)

Lesson 5
Voyager Missions

Lesson Material

The twin Voyager 1 and 2 spacecraft continue exploring where nothing from Earth has flown before. In the 25th year after their 1977 launches, they each are much farther away from Earth and the Sun than Pluto is and approaching the boundary region -- the heliopause -- where the Sun's dominance of the environment ends and interstellar space begins. Voyager 1, more than twice as distant as Pluto, is farther from Earth than any other human-made object and speeding outward at more than 17 kilometers per second (38,000 miles per hour). Both spacecraft are still sending scientific information about their surroundings through the Deep Space Network (DSN).

The primary mission was the exploration of Jupiter and Saturn. After making a string of discoveries there -- such as active volcanoes on Jupiter's moon Io and intricacies of Saturn's rings -- the mission was extended. Voyager 2 went on to explore Uranus and Neptune, and is still the only spacecraft to have visited those outer planets. The adventurers' current mission, the Voyager Interstellar Mission (VIM), will explore the outermost edge of the Sun's domain. And beyond.
(http://voyager.jpl.nasa.gov/mission/mission.html)

The Voyager mission was designed to take advantage of a rare geometric arrangement of the outer planets in the late 1970's and the 1980's. This layout of Jupiter, Saturn, Uranus and Neptune, which occurs about every 175 years, allows a spacecraft on a certain flight path to swing from one planet to the next without the need for large on board propulsion systems. The flyby of each planet bends the spacecraft's flight path and increases its velocity enough to deliver it to the next destination. Using this "gravity assist" technique, the flight time to Neptune can be reduced from 30 years to 12.

While the four-planet mission was known to be possible, it was decided it was going to be too expensive to build a spacecraft that could go the distance, carry the instruments needed and last long enough to finish the mission. The Voyagers were funded to conduct intensive flyby studies of Jupiter and Saturn only. More than 10,000 trajectories were studied before choosing the two that would allow close flybys of Jupiter and its large moon Io, and Saturn and its large moon Titan.

Jupiter

Jupiter is the fifth planet from the Sun, and the largest in our solar system. It takes 11.82 years for Jupiter to orbit the Sun, and 9 hours and 50 minutes to complete a rotation around its axis. Unlike the other planets, Jupiter rotates around its axis counter clockwise. Its gravity is 2.64 times that of the Earth's. The planet is composed of 88% hydrogen and 11% helium gas; it contains 70% of all the matter that make up the planets. Many locations on Jupiter have temperatures that could sustain life, however powerful storms like the Red Spot, in addition to the fact that the planet is made up of gas, makes life on Jupiter impossible. Jupiter has 16 natural satellites; Lo, the largest moon in the solar system, exhibits more volcanic activity than any other moon.

Jupiter's orbit is 778,330,000 km from Sun.
Jupiter's diameter is 142,984 km.

Jupiter's mass is 1.900e27 kg.

Saturn

Saturn is the sixth planet from the Sun, and is the second largest in our solar system. Its gravity is 1.14 times stronger than the Earth's, and like Jupiter it is made up of mostly hydrogen and helium. However, Saturn's core is believed to be composed of water, methane, and ammonia. Saturn's most obvious characteristic the millions of thin rings that circle around the planets orbital plane. The planet also has more natural satellites than any other planet in the solar system, with a count within 21-23. Titan, one of Saturn's moons, has an organic atmosphere made up off nitrogen and hydrogen cyanide. This is the only place in the solar system where hydrogen cyanide has been found.

Saturn's orbit is 1,429,400,000 km from Sun.

Saturn's diameter is120,536 km.

Saturn's mass is 5.68e26 kg the chosen flight path for Voyager 2 also preserved the option to continue on to Uranus and Neptune.

From the NASA Kennedy Space Center at Cape Canaveral, Florida, Voyager 2 was launched first, on August 20, 1977; Voyager 1 was launched on a faster, shorter trajectory on September 5, 1977. Both spacecraft were delivered to space aboard Titan-Centaur expendable rockets.

The prime Voyager mission to Jupiter and Saturn brought Voyager 1 to Jupiter on March 5, 1979, and Saturn on November 12, 1980, followed by Voyager 2 to Jupiter on July 9, 1979, and Saturn on August 25, 1981. Voyager 1's trajectory, designed to send the spacecraft closely past the large moon Titan and behind Saturn's rings, bent the spacecraft's path inexorably northward out of the ecliptic plane -- the plane in which most of the planets orbit the Sun. Voyager 2 was aimed to fly by Saturn at a point that would automatically send the spacecraft in the direction of Uranus.

After Voyager 2's successful Saturn encounter, it was shown that Voyager 2 would likely be able to fly on to Uranus with all instruments operating. NASA provided additional funding to continue operating the two spacecraft and authorized JPL to conduct a Uranus flyby. Subsequently, NASA also authorized the Neptune leg of the mission, which was renamed the Voyager Neptune Interstellar Mission.

Voyager 2 encountered Uranus on January 24, 1986, returning detailed photos and other data on the planet, its moons, magnetic field and dark rings. Voyager 1, meanwhile, continues to press outward, conducting studies of interplanetary space. Eventually, its instruments may be the first of any spacecraft to sense the heliopause -- the boundary between the end of the Sun's magnetic influence and the beginning of interstellar space.

Following Voyager 2's closest approach to Neptune on August 25, 1989, the spacecraft flew southward, below the ecliptic plane and onto a course that will take it, too, to interstellar space. Reflecting the Voyagers' new transplanetary destinations, the project is now known as the Voyager Interstellar Mission.
(http://www.solarviews.com/eng/vgrfs.htm)

Uranus

Uranus is the seventh planet from the Sun. Uranus' force of gravity is 1.04 times stringer than that of Earth. Like Jupiter and Saturn, the planet is made up mostly of hydrogen and helium. A unique characteristic of this planet is that it rotates on an axis that lies within it orbital plane. As a result, Uranus appears to "roll" along its orbit from "above." No other planet exhibits this type of rotation. Uranus also has a set of 10 rings, however unlike Saturn, they don't lie on the planet's orbital plane, but rather the planet's north and south poles. Uranus has five moons.

Uranus' orbit is 2,870,990,000 km from Sun.
Uranus' diameter is 1,118 km.
Uranus' mass is 8.683e25 kg.

Neptune

Neptune is the eighth planet from the Sun, and is the fourth largest planet in our solar system. It takes Neptune 165 years to orbit the Sun, and 5.8 hours to complete one rotation around its axis. Because of Neptune's highly eccentric orbit, it is sometimes the farthest planet from the Sun.

Neptune's orbit is 4,504,000,000 km from Sun.
Neptune's diameter is 49,532 km.
Neptune's mass is 1.0247e26 kg

Pluto

Pluto is the ninth planet from the Sun, and is also the smallest planet in the solar system. From Pluto, the Sun only appears as a bright star. Pluto is the only planet that does not lie in the same plane as the others. The planet is composed of half rock, and half methane frost, it has one moon, Charon.

Pluto's orbit is 5,913,520,000 km from the Sun.
Pluto's diameter is 2274 km.
Pluto's mass is 1.27e22 kg

Voyager 1 is now leaving the solar system, rising above the ecliptic plane at an angle of about 35 degrees at a rate of about 520 million kilometers (about 320 million miles) a year. Voyager 2 is also headed out of the solar system, diving below the ecliptic plane at an angle of about 48 degrees and a rate of about 470 million kilometers (about 290 million miles) a year.

Both spacecraft will continue to study ultraviolet sources among the stars, and the fields and particles instruments aboard the Voyagers will continue to search for the boundary between the Sun's influence and interstellar space. The Voyagers are expected to return valuable data for two or three more decades. Communications will be maintained until the Voyagers' nuclear power sources can no longer supply enough electrical energy to power critical subsystems.

The cost of the Voyager 1 and 2 missions -- including launch, mission operations from launch through the Neptune encounter and the spacecraft's nuclear batteries (provided by the Department of Energy) -- is $865 million. NASA budgeted an additional $30 million to fund the Voyager Interstellar Mission for two years following the Neptune encounter.

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Lesson 6
Hubble Space Telescope

In 1962 the National Academy of Sciences recommended building a large space telescope. Putting a telescope in space would allow astronomers a better view of the universe, since they wouldn't have to peer through the blurriness of Earth's atmosphere. It took many years but in 1977 Congress voted to fund the project and construction of Hubble Space Telescope begins. The telescope will be the size of a school bus. In 1985 Construction of Hubble Space Telescope was completed. Hubble's giant mirror weighs one ton and took three years to grind and polish.

On April 25, 1990 Astronauts on the space shuttle Discovery launch the Hubble Space Telescope into orbit around Earth. Within days there is bad news. Hubble is sending back pictures that are out of focus. On December 1993 Astronauts on the space shuttle Endeavour repair the telescope, adding a camera to correct problems with the telescope's primary mirror. The giant mirror was too flat on one edge by 1 / 50th of the width of a single human hair. Hubble's new pictures bring sharp focus to our distant surroundings.

In February 1997 A second servicing mission. Astronauts swap out some of Hubble's instruments and give Hubble some nice new blankets to keep it warm. It was getting too cold in the vastness of space. October 1997: NASA decided to extend Hubble's operations from 2005 to 2010. It was still producing viable information and reliable photos. Now NASA wants to disable the Hubble even though it is still operable. This is causing a huge debate in the science field. It was expected that Hubble would be in service for much longer, but NSAA wants to move on to other things

The primary mirror of the Hubble telescope measures 2.4 m (8 ft) in diameter and weighs about 826 kg (1820 lbs). It is constructed of ultra-low expansion silica glass and coated with a thin layer of pure aluminum to reflect visible light. A thinner layer of magnesium fluoride is layered over the aluminum to prevent oxidation and to reflect ultraviolet light. It cost over One Billion dollars and was not NASA's idea of a telescope they wanted.

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(Final Preparations)

Shortly after this image was taken, the Hubble telescope was shipped to Kennedy Space Center and loaded into the cargo bay of the shuttle Discovery. The telescope measures 13.1 m (43.5 ft) in length, 4.27 m (14.0 ft) in diameter, and weighs 11,000 kg (25,500 lb). Note the size of the workers standing near the base of the telescope. Also note the orange cylinder attached to the telescope; this is one of the two solar arrays that provide power to Hubble's batteries. Once unrolled in orbit, each array will be over 12 m (40 ft) long and provide 1200 watts of power.

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(Launch)

The Hubble Space Telescope was first scheduled for launch in 1986. But due the tragic loss of the shuttle Challenger in late January of that year, the launch was delayed four years. In April 1990, the Hubble telescope was lifted into orbit aboard the shuttle Discovery.

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(Deployment)

Crew members aboard the shuttle Discovery shot this photograph April 25, 1990. It shows the deployment of the Hubble Space Telescope from the payload bay, guided by the shuttle's robotic arm. The giant spaceborne telescope was put into orbit to collect information about a large variety of astronomical objects, from neighboring planets and stars to the most distant galaxies and quasars.

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(Aiming the Telescope)

This artist's concept is a view from near the Hubble telescope, looking back at the shuttle Discovery shortly after deployment. The telescope's tracking system is very accurate. The pointing system comprises reaction wheels that actually move the telescope, gyros that report its position, star trackers that provide reference points, and the onboard computer that controls the pointing process.

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(Relaying Data)

The path by which Hubble data arrive on Earth is outlined here. Images received by the telescope are converted into digital code and radioed to Earth using high-gain antennas at

a rate of one million bits per second. Once the digital code is received by ground stations, it is converted into photographs or spectrograph readings for use by scientists.
(Verbatim http://www.astronomical.org/planets/welcome/hubble.htm)

Lesson 7
Apollo Missions

On May 25, 1961, U.S. President Kennedy, reacting to Soviet advances in space exploration, put forth a challenge in the House of Congress. "I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the earth," he said. Behind the statement though, were two realities. The cold war was heating up, Cuban missile crisis was in the mists of world panic, President Kennedy wanted a Non-Military way to "compete" with the Soviet Union and demonstrate techno-military power. Kennedy's advisors assured him It was possible and that the goal was sufficiently far from then current Soviet capabilities, and that we'd have plenty of time to catch up and surpass them.

Several methods to reach the moon were considered and documented, but only one idea had a chance to succeed by Kennedy's deadline. Scientists chose to use a technique called the Lunar Orbit Rendezvous, which in a way involved using two sets of spacecraft for one flight.

The result was the "Apollo Stack". It was made up of three modules and a booster. The command module served as the crew's quarters and flight control section. The Service Module was used for the propulsion and spacecraft support systems. The command and service modules together were called the Command-and-Service Module, or CSM. The Lunar Module transported two crewmembers to the lunar surface and back to the waiting CSM.

The three modules that made the spacecraft sat on top of the Saturn V and Saturn IB launch vehicle The Saturn V was used for all lunar flights. The Earth orbit flights used the Saturn IB booster.

Apollo missions 1 and 7 through 10 were designated Earth and Lunar Orbital Missions. Missions 11 through 17 were Lunar Landing Missions, although Apollo 13 failed to reach the moon's surface. The six successful lunar landings yielded almost 400 kilograms of samples. Astronauts returned 21 kilograms of samples from the Apollo 11 mission. This amount increased during each expedition, ultimately resulting in 110 kilograms of samples from the Apollo 17 mission.

Astronauts spent increasingly more time on the surface as well. During Apollo 11, Neil Armstrong and Edwin "Buzz" Aldrin spent just two hours and 24 minutes on the moon's surface. By Apollo 17, Eugene Cernan and Harrison Schmitt enjoyed 22 hours and five minutes of spacewalking and lunar rover travel. Experiments performed during the Apollo missions studied soil mechanics, meteoroids, seismic activity, heat flow, lunar ranging, magnetic fields and solar wind.

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There are a few pieces of information that the Apollo missions specifically helped us learn about the moon. Ten of them are:

1. The moon has evolved and has a similar internal zoning to Earth.

2. The history of the moon's first billion years is preserved, and is likely the same as all terrestrial planets.
3. The moon's youngest rocks are approximately as old as Earth's oldest rocks. Affects from early events that had an impact on both Earth and the moon can now only be observed on the moon.
4. The moon and Earth were made out of the same materials in different proportions.
5. The moon is void of life. No living organisms, fossils or native organic compounds were found.
6. All moon rocks are basalts, anorthosites or breccias. Water was not necessary for their formation.
7. An ocean of magma existed on the moon in its earlier years. Remnants of rocks that floated to the ocean's surface are still found on the surface.
8. Asteroid impacts created basins, later filled by lava from the magma ocean.
9. The moon is asymmetrically formed. It has a thicker crust on the far side and larger mass concentrations on the near side.
10. Rock fragments and dust, called the lunar regolith, cover the moon's surface. This provides a history of the sun's radiation, which is important to studying climate change on Earth.
(http://www.nasm.si.edu/collections/imagery/apollo/apollo.htm)

Lesson 8
The Rover

After the Viking missions, there was not a lot of support for continued mars exploration. That was of course until recently. A meteorite was found in Antarctica. It is believed that it came from Mars 4.5 billion years ago. Every day 2 meteorites hit the ground, but because Antarctica is all snow and ice, it preserves the meteorite. The interesting thing about this meteorite was that it contained what resembled a for of organism. A distinctive sign of life from mars fallen right into our laps.

After the meteorite was discovered with potential life, NASA's interest in another mission to mars rose again. NASA constructed a new series of space vehicles, they were called the rovers. The rovers were small planet roaming vehicles that were remote controlled via satellite from mars, their mission was to gather and collect data about the soil and chemical makeup.

Currently, there are expeditions to the Arctic in progress with their goal of finding more meteorites. They are combing glaciers in a 50-foot grid for a 100-mile radius. They have spent months on end looking at these glacier flows, and are very hopeful they will find something. The reason that they are looking at these ice flows is precisely because they are so old and slow moving. Something from 4.5 billion years ago is still there in new condition. They all flow into this certain area just like a river into the ocean. So most likely, the meters that have fallen will eventually end up there. Its not that Antarctica has more meteorites than anywhere else, but it is a central place to look, and more likely that they will still be there un affected by life on earth.

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(MARS ROVER)

Moving from place to place, the rovers will perform on-site geological investigations. Each rover is sort of the mechanical equivalent of a geologist walking the surface of Mars. The mast-mounted cameras are mounted 1.5 meters (5 feet) high and will provide 360-degree, stereoscopic, humanlike views of the terrain. The robotic arm will be capable of movement in much the same way as a human arm with an elbow and wrist, and will place instruments directly up against rock and soil targets of interest. In the mechanical "fist" of the arm is a microscopic camera that will serve the same purpose as a geologist's handheld magnifying lens. The Rock Abrasion Tool serves the purpose of a geologist's rock hammer to expose the insides of rocks.

The Mars Exploration Rovers, launched toward Mars on June 10 and July 7, 2003, in search of information about the water on Mars. The Mars Exploration Rover mission is part of NASA's Mars Exploration Program, a robotic exploration of the red planet.

The mission's scientific goals is to search for and categorize a large array of rocks and soils that hold clues to past water activity on Mars. The spacecraft are targeted to sites on opposite sides of Mars that appear to have been affected by liquid water in the past. The landing sites are at Gusev Crater, a possible former lake in a giant impact crater, and Meridiani Planum, where mineral deposits (hematite) suggest Mars had a wet past.

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(MARTIAN ICECAP AND SURFACE)

After the airbag-protected (kind of like a beach ball) landing craft settle onto the surface and open, the rovers will roll out to take panoramic images. These will give scientists the information they need to select promising geological targets that will tell part of the story of water in Mars' past. Then, the rovers will drive to those locations to perform on-site scientific investigations over the course of their 90-day mission.

The Rovers instruments are meant primarily for documentation and recording and learning about soil.

- Panoramic Camera (Pancam): for determining the mineralogy, texture, and structure of the local terrain.

- Mössbauer Spectrometer (MB): for close-up investigations of the mineralogy of iron-bearing rocks and soils.

- Alpha Particle X-Ray Spectrometer (APXS): for close-up analysis of the abundances of elements that make up rocks and soils.

- Miniature Thermal Emission Spectrometer (Mini-TES): for identifying promising rocks and soils for closer examination and for determining the processes that formed Martian rocks. The instrument will also look skyward to provide temperature profiles of the Martian atmosphere.

- Magnets: for collecting magnetic dust particles. The Mössbauer Spectrometer and the Alpha Particle X-ray Spectrometer will analyze the particles collected and help determine the ratio of magnetic particles to non-magnetic particles. They will also analyze the composition of magnetic minerals in airborne dust and rocks that have been ground by the Rock Abrasion Tool.

• Microscopic Imager (MI): for obtaining close-up, high-resolution images of rocks and soils.

• Rock Abrasion Tool (RAT): for removing dusty and weathered rock surfaces and exposing fresh material for examination by instruments onboard.

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(Rover Mission path explorer over its life, including the geological sites surveyed)

Lesson 9
Debate Preparation

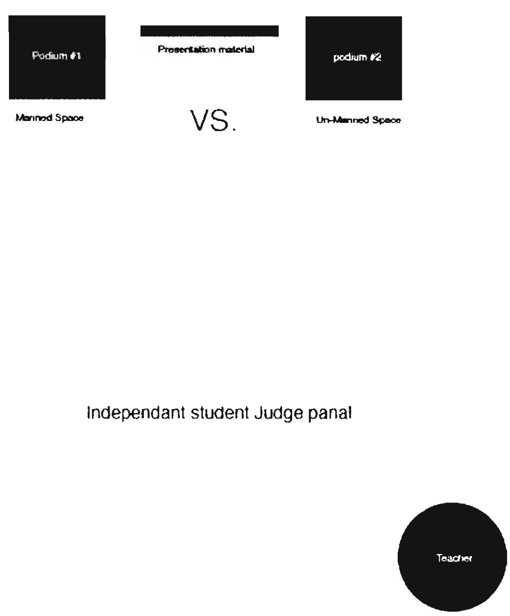
This class is dedicated to splitting the class into different debate groups and allowing the groups to discuss and set up a stance on which form of space travel is more beneficial to the United States the class should be split up into groups of 5 people each. Each group should then be paired with another group to be its "debate buddy". Topic about manned vs. unmanned space should be divided up between the two groups. One side taking manned space, and the other taking un-manned space.

The teacher should bring some sort of candy or something like that to give to the students for them to use as fake money, and they have to debate with the other group whether or not they can achieve the same information using manned or unmanned space, and be able to present their findings during a debate in the next class.

The debate should be put in a political like debate setting, with podiums, and charts and graphs each proving their side. The other groups will be an independent panel on the information provided and will vote on the winner of the debate, and where the money should go too.

Set-ups that will be needed for the debate are:

1. A quantity of small candies or some sort of distributable food
2. Poster boards
3. Pictures of visual aids
4. Groups of 5 paired
5. Markers and Pens
6. Chairs to be set up correctly
7. 2 podiums



(Debate room setup)

The debate is based on the manned VS unmanned space missions and students can use any information either found through research or learned in class to prepare for the debate. They should be given the rest of this class time to set up their group structure and divide up their prep work.

Lesson 10
Debate and Conclusion

This class is dedicated to the actual debate of the issue of manned VS. unmanned space travel. After the debate is concluded there will be a wrap up session where a winner for the debate is decide and an evaluation of the material covered will be given.

Handouts

Handout 1

This is a document off of the White Houses website describing the plan of Space Exploration for the next 10-20 years. The document came from the website at the url: http://www.whitehouse.gov/space/renewed_spirit.html.

Background

From the Apollo landings on the Moon, to robotic surveys of the Sun and the planets, to the compelling images captured by advanced space telescopes, U.S. achievements in space have revolutionized humanity's view of the universe and have inspired Americans and people around the world. These achievements also have led to the development of technologies that have widespread applications to address problems on Earth. As the world enters the second century of powered flight, it is time to articulate a new vision that will define and guide U.S. space exploration activities for the next several decades.
Today, humanity has the potential to seek answers to the most fundamental questions posed about the existence of life beyond Earth. Telescopes have found planets around other stars. Robotic probes have identified potential resources on the Moon, and evidence of water -- a key ingredient for life -- has been found on Mars and the moons of Jupiter.
Direct human experience in space has fundamentally altered our perspective of humanity and our place in the universe. Humans have the ability to respond to the unexpected developments inherent in space travel and possess unique skills that enhance discoveries.
Just as Mercury, Gemini, and Apollo challenged a generation of Americans, a renewed U.S. space exploration program with a significant human component can inspire us -- and our youth -- to greater achievements on Earth and in space.
The loss of Space Shuttles Challenger and Columbia and their crews are a stark reminder of the inherent risks of space flight and the severity of the challenges posed by space exploration. In preparation for future human exploration, we must advance our ability to live and work safely in space and, at the same time, develop the technologies to extend humanity's reach to the Moon, Mars, and beyond. The new technologies required for further space exploration also will improve the Nation's other space activities and may provide applications that could be used to address problems on Earth.
Like the explorers of the past and the pioneers of flight in the last century, we cannot today identify all that we will gain from space exploration; we are confident, nonetheless, that the eventual return will be great. Like their efforts, the success of future U.S. space exploration will unfold over generations.

Goals and Objectives

The fundamental goal of this vision is to advance U.S. scientific, security, and economic interests through a robust space exploration program. In support of this goal, the United States will:
Implement a sustained and affordable human and robotic program to explore the solar system and beyond;
Extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations;

Develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about the destinations for human exploration; and
Promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests.

Bringing the Vision to Reality
The Administrator of the National Aeronautics and Space Administration will be responsible for the plans, programs, and activities required to implement this vision, in coordination with other agencies, as deemed appropriate. The Administrator will plan and implement an integrated, long-term robotic and human exploration program structured with measurable milestones and executed on the basis of available resources, accumulated experience, and technology readiness.
To implement this vision, the Administrator will conduct the following activities and take other actions as required:

A. Exploration Activities in Low Earth Orbit
Space Shuttle
Return the Space Shuttle to flight as soon as practical, based on the recommendations of the Columbia Accident Investigation Board;
Focus use of the Space Shuttle to complete assembly of the International Space Station; and
Retire the Space Shuttle as soon as assembly of the International Space Station is completed, planned for the end of this decade;
International Space Station
Complete assembly of the International Space Station, including the U.S. components that support U.S. space exploration goals and those provided by foreign partners, planned for the end of this decade;
Focus U.S. research and use of the International Space Station on supporting space exploration goals, with emphasis on understanding how the space environment affects astronaut health and capabilities and developing countermeasures; and
Conduct International Space Station activities in a manner consistent with U.S. obligations contained in the agreements between the United States and other partners in the International Space Station.

B. Space Exploration Beyond Low Earth Orbit
The Moon
Undertake lunar exploration activities to enable sustained human and robotic exploration of Mars and more distant destinations in the solar system;
Starting no later than 2008, initiate a series of robotic missions to the Moon to prepare for and support future human exploration activities;
Conduct the first extended human expedition to the lunar surface as early as 2015, but no later than the year 2020; and
Use lunar exploration activities to further science, and to develop and test new approaches, technologies, and systems, including use of lunar and other space resources, to support sustained human space exploration to Mars and other destinations.
Mars and Other Destinations

Conduct robotic exploration of Mars to search for evidence of life, to understand the history of the solar system, and to prepare for future human exploration;
Conduct robotic exploration across the solar system for scientific purposes and to support human exploration. In particular, explore Jupiter's moons, asteroids and other bodies to search for evidence of life, to understand the history of the solar system, and to search for resources;
Conduct advanced telescope searches for Earth-like planets and habitable environments around other stars;
Develop and demonstrate power generation, propulsion, life support, and other key capabilities required to support more distant, more capable, and/or longer duration human and robotic exploration of Mars and other destinations; and
Conduct human expeditions to Mars after acquiring adequate knowledge about the planet using robotic missions and after successfully demonstrating sustained human exploration missions to the Moon.

C. Space Transportation Capabilities Supporting Exploration
Develop a new crew exploration vehicle to provide crew transportation for missions beyond low Earth orbit;
Conduct the initial test flight before the end of this decade in order to provide an operational capability to support human exploration missions no later than 2014;
Separate to the maximum practical extent crew from cargo transportation to the International Space Station and for launching exploration missions beyond low Earth orbit
Acquire cargo transportation as soon as practical and affordable to support missions to and from the International Space Station; and
Acquire crew transportation to and from the International Space Station, as required, after the Space Shuttle is retired from service.

D. International and Commercial Participation
Pursue opportunities for international participation to support U.S. space exploration goals; and
Pursue commercial opportunities for providing transportation and other services supporting the International Space Station and exploration missions beyond low Earth orbit.

Goals and Objectives
The fundamental goal of this vision is to advance U.S. scientific, security, and economic interests through a robust space exploration program. In support of this goal, the United States will:
Implement a sustained and affordable human and robotic program to explore the solar system and beyond;
Extend human presence across the solar system, starting with a human return to the Moon before the year 2020, in preparation for human exploration of Mars and other destinations;
Develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about the destinations for human exploration; and

Promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests.

Appendix F – The letter to the students from WPI

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Dear _________:

I am one of three students working with Professor John Wilkes at WPI, on a study to find a science and/or social studies curriculum format that is a good match for students with each of four different learning styles. The four different learning styles (SJ, SP, NJ, and NP) can be identified using the Myers Briggs Type Indicator (MBTI). The focus on science and social studies is due to the existence of some successful curricula that mix the two subjects quite effectively, using social issues to motivate scientific and technological literacy.

We are seeking to perform our curriculum evaluation work focusing on the 8^{th}-9^{th}-grade population. Our central goal is to help improve the performance of the SJ learning type that struggles most on the Massachusetts Comprehensive Assessment System (MCAS), giving them a better chance to succeed on the MCAS. However, along the way we hope to find curricula that are good matches for all four types of learners.

Two previous series of studies provide a foundation for our proposal. The first studies were conducted from 1992-1997, involving the development and evaluation of about a dozen S-STS (teaching Science through the medium of Science, Technology and Society) curriculum modules. These studies were typically evaluated using the MBTI as a learning styles measure, so we have some idea of whose performance improved the most on the S-STS units. The second began in 1998 when MCAS practice testing began in Worcester. At that time the MBTI was administered to the Worcester Public Schools classes of 2000-2003, and the results linked the students' learning type to their MCAS scores. These studies made it clear which types of learners were most at risk in terms of under performing on this required test. Compared to other students in high school classes of the same level of difficulty, the SJ's and especially the ESJ's were at greater risk of underperforming.

Our proposed study would involve taking three to five classes of 8^{th} or 9^{th} grade students and administering the MBTI instrument to them. The classes of students would then be divided into experimental and control groups. The experimental group would then be taught using S-STS curricula designed to suit or enhance the ease of learning for a type of learner learning. The control group would be taught the standard curricula that was not structured to suit a certain learning style, but might be biased towards one type of learner inadvertently.

For your convenience, we can build this project around any of the school's current studies involving various curricula. Alternatively, we can use one or more of the WPI curriculum units, that teach the concepts of science through the context of social issues and social problem also know as the S-STS curricula. These S-STS (Science through the medium of Science, Technology and Society) curriculum modules were designed at WPI in the mid 1990's, tended to improve the grades of the ESF learning types. The learning type that most frequently struggles on the MCAS tests is the SJ. However, other S-STS units, such as Chemcom (Chemistry in the Community), which was developed by the American Chemical Society for high school students were more successful with ENF learners. We think the key difference in the response of S and N students is whether the science concepts are introduced first or the social issue is covered first, to frame the unit. Previous studies have shown that N types do tend to do better with abstractions, but our theory is only plausible since it has not been tested. Finally, this study can help give insight on how to develop science curricula for all the kinds of students to reach a sufficient level of science mastery to perform well on the MCAS. We want to do this while enhancing their social studies background as well, at least for those types that are comfortable with mixing subjects in ways that increase the complexity of the materials.

In closing we would like to schedule a meeting with you to discuss the options that you would consider setting up a project in your school. With a budget of $450.00 we will be able to profile about 150 students using the MBTI. If you would like to profile more than 150 students financial assistance will be required. We will be bringing a more detailed explanation of our project at the meeting.

Sincerely,
Matthew Racki
85 Salisbury St.
Worcester, MA 01609

Appendix G – The Survey

This survey is composed of nine questions that will be used to measure certain features of this curriculum. Please answer all questions thoroughly and honestly. Thanks for your time.

1. How informative was this curriculum? (1=Not informative, 6= Very informative) Please explain.

2. How well did the curriculum hold your attention (1=Not well, 6=Very Well)

3. What held your attention the most? the least?

4. How many things did you not like about this curriculum? What was the thing you disliked the most?

5. Were there any parts that you wanted to read more about? (If yes, please explain)

6. (a = Lab b = No Lab)
    a. How much did the lab help reinforce the concepts learned in the curriculum?

    b. How much would a lab help reinforce the concepts learned in the curriculum?

7. How different was this curriculum from one you were taught in the 8th grade?(1=Not Different, 6=Very Different)

8. Did you have a favorite lesson? (If yes, which one and why?)

9. How relevant was the the information learned to your role as a citizen in the U.S.?

Appendix H – The Data Collected

responsesfinal.xls

Appendix I – Bibliography