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Curricula Development with an MBTI approach

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This is a section of the *Curriculum Development with an MBTI Approach* Interdisciplinary Qualifying Project, by Spyros Photopoulos et al.. The content of this document includes only the first part of the full report; the introduction and the literature review sections of the report. The remaining items listed in the table of contents (including the bibliography) will be submitted separately by Matt Racki and Andreas Krankle upon completion of their part of the report in A term of 2004.

Abstract

Our goal is to find a science and/or social studies curriculum format that is a good match for 7^{th}-8^{th} grade students with each of four different learning styles. A few prior studies allowed us to identify what type of learners, in MBTI terms, underperformed on the state achievement test. Other prior studies allowed us to identify a curriculum format especially likely to be effective in holding the attention of that type of learner. This study was a test to see if we could predict which of two curricula covering the same (solar system) material, the type of learner at risk would prefer.

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1.0 Introduction

In 1993 the Commonwealth of 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, hoping to successfully completing the exam in time to graduate. When practice testing began on the MCAS, the Worcester Public Schools decided to administer the Myers-Briggs Type Indicator (MBTI) instrument for four years to those students who were taking the three practice and the first official MCAS tests.

The MBTI had previously been used in a study involving students' PSAT and SAT scores from the Worcester Public School experience with the classes of 1996-1999 so this decision study extended the MBTI database from 2000 to 2003, for a total of eight years.. In the SAT study, there were striking differences in test scores associated with the Sensing (S) - Intuitive (N) and Judging (J) - Perceiving (P) dimension of the learning style indicator. WPI students getting credit through the IQP program, combined the MCAS and MBTI data for 2000 and 2001. Paid help did them for 2002 and 2003. These datasets permitted 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 tests and as a result they were not ready by 2001 so the first studies focused on English and Math MCAS tests.. This study showed that a certain MBTI learning type (SJ) was more likely to under perform on the two MCAS tests than any other type, not only on the Math and English subjects, but also on the (not yet offered) Science and History tests too. Our goal is to help improve the odds for success of the SJ learning type (the one most likely to fail all subjects), by testing a few different science curricula, looking for one that is especially effective for students of 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 at the time. We hope that specialists in this field will see analogies not evident to us.

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, format 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 about a dozen S-STS curriculum units suitable for 4^{th} to 9^{th} grade were developed teaching several different science subjects. The majority were billed as 6^{th} grade units. 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 citizenry through its social consequences.

Our study involved creating two different 8th grade science curricula units with focus on the topics of NASA; policy of emphasizing manned space missions and our understanding of the solar system, and the planets. While one of the curricula units was written in so as to reflect the curriculum guidelines of the traditional Massachusetts Curriculum Framework, the latter was developed with and S-STS curriculum format fostered by Rustrum Roy, Leonard Walts, and others at Penn State in the 1990's.. The study design then involved taking 48 college students, and dividing them into four groups of 12. The students were split up based on their scores on two of the four MBTI dimensions so as to be either: NP, SP, NJ, or SJ. From the 12 students per group, 6 were to read and rate the traditional curriculum unit that was developed, while the other 6 read and rated 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 were asked 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 75%-90% of all entering freshman, varying by class, 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 from their classes archive.

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. The main problem in doing it with real 8th graders is that the MBTI is suitable for people with a high school level of education. In practice that has meant it should not be used with students earlier than 9th grade. The MMTIC is used with 3rd to 8th graders and it is not as reliable, requiring verification at the individual level, hence gathering data from real 8th graders will be complicated and time consuming as well as costly. 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. Over a dozen studies have been conducted (mostly at the 6th grade level) to relate MBTI learning types to different educational processes and outcomes, such as test protocols and curriculum formats. A focus of this work has been the evaluation of S-STS curriculum. More recently research focus has shifted to MCAS performance. An example thus can be seen in the class of 2003 study, which compared the data from the 2001 10th grade MCAS scores to the MBTI learning types. The 8th grade MCAS scores for their second group of students were also produced. 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 or grade level (8th or 10th grade.. On the other hand, students taking more challenging courses (Honors and AP) tended to do better on the MCAS as whatever their learning style, compared to same type students with less challenging course preparation.. It was best to compare the learning styles of students who had the same preparation 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 by Isabel Myers, and her mother Katharine Briggs, the authors of the Form A test type. The

standard version of the MBTI was Form G (having 126 of the 167 items from Form F) for many years. That was Isabel's last personal effort. Now, Form M offered by CC Press is the new standard, however WPI used form G 5 out of 6 times 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 it was first 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's Press took over the marketing and distribution 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 and effective in dealing with 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. 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. Isabel hoped that the MBTI would be used to help people find jobs and careers that they would love, and that were a good fit given their individual performances.

After being 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 developed to identify the dominant and auxiliary functions. The strategy that Isabel 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, and then tally up the proportion of times one responds as one or the other to the preferences in order to see if there is 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 on the form G 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 function gets 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 they prefer to operate in. *(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 most closely linked to a person's learning style. A sensing learning type tends to learn best where one starts with practical and factual details, whereas the intuitive learning types tend to perceive with their memory as their observer and make associations as they gather information. Since the intuitive types work out of their memory more, rather than their senses they tend to want to start with abstractions and take more on the specific facts. Intuitive types appear to "get it" fast and to learn faster in classes. Sometimes this is deceptive as they have not fully mastered the details of the concept where they can articulate it. Most of the intuitive types will seek greater challenges and 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 be attracted to science and mathematics classes and programs. On the other hand, feeling types tend to prefer subjects that relate more to personal experiences and meaning such as English and Language Arts. Some aspects of the arts, humanities and social studies also seem to appeal to them.

2.3 MCAS

In the past couple of years the Massachusetts educational system has evolved in an effort to adapt new curricula focused on providing students with the adequate knowledge to perform well on the Massachusetts Comprehensive Assessment System (Test) (MCAS). After the Education Reform Law was passed in 1993, the new MCAS assessments were introduced to test nearly 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, 10^{th} grade students across the commonwealth were the first to undertake in the MCAS tests in math and ELA. (The other tests were not ready for official approval) Their results would determine the individual's eligibility for earning a high school diploma. The 1 in 3 who failed the first time would have more chances to pass the test in their 11^{th} and 12^{th} grade years. However, if they still did not pass they would only get a certificate of attendance, not a diploma from the local school district.

The MCAS is comprised of four different question types: multiple choice, open response, short answer, and writing prompts. These different question types are each scored differently. 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. In the English compositions spelling, grammar, etc do count.

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 preparation, knowledge and/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 or 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 school 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; second domains of factual information and concepts; technology; and "science and technology as they relate to human affairs". Later Sciences, Technology and Human Affairs" was moved to social studies at the request of the science teachers. The technology section was originally a two part unit divided between design consideration and a Technology-Society interaction section. It is now focused on design issues as the technology educations were merged to change the social implications material that many found to be subjective and hard to grade consistently. They also felt that if they could not teach the subjects i.e. tell them what the right answers are and defend them they should asses the students in these. Ironically, the Technology Education had no trouble viewing design as a process they could teach with out having right answers. Throughout the different content strands the students are to engage in solving problems, evaluating evidence, and searching for connections. There is a real effort to get away from teaching facts to be memorized and delivered back on the exams.

- *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 which variables were to be either controlled, changed, and measured as outcomes. The next goals are to address and analyze questions through the application 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 content in this area of 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 was 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 in which technological devices have improved the quality of life for individuals. That is what was dropped, and the implication of that decision were unexpectedly fan reaching.

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 and focus on the social implications of technological change and scientific advance, without are tactically a result in social progress. It was conceived of as citizenship training for people living in a democratic

society. While furthering personal knowledge of the science curriculum and fulfilling the required knowledge needed to successfully live and work in a technological society it was an outgrowth of what Penn State called the technological Literacy Movement. Prior studies have proved that the S-STS curriculum format is a good method for personally involving students with the subject matter by making the case for its relevance. It also encouraged for the students to search out new knowledge for themselves. The hallmark for an STS unit is to start with a social issue and teach the science on a "need to know" basis while exploring the public policy issue. As such, it is the inverse of the traditional curriculum which starts with the science, a widely abstract conceptual formulation and moves toward a specific illustration on application at the end. All too often the reinforcing activity at the end gets short shrift or is never regarded due to time constraints. In theory traditional STS curricula only change the order of presentation not the content to be covered.

The S-STS curricula developed by the project groups in 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 range 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] Evaluation of the WPI 6th Grade STS Initiative, Maria A Salvati, 9/18/1996

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 and questions 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 essentially "diluting" the science and reducing the amount of content covered (but possibly not what is retained). 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. They will remember and know how to use more of what they were exposed to. 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 it grounds the future technologist in the habit of thinking about what is at stake for society in how things are done, rather than teaching them to think exclusively in terms of capital costs and efficiency criteria.. 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 engage the science material as

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

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. 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. They are less common among scientists and in the engineering community or in the university level were generally.

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 curriculum formats. But, the sensing type students were at a higher risk of not gaining as much knowledge mastery from the current abstract and generalized science text and courses. They were expected to do better if they were applied or "hands on, in emphasis." After more research and testing, some WPI

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

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 than before. The longer the S-STS experiment lasted, the more 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 substantially improved their overall grade (especially in the second unit) while 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 opportunity for students to involve themselves in the technical side of the work and those that do so rarely get to use their knowledge in an applied fashion. One more criticism of the S-STS curriculum format is that it takes time away from teaching about science concepts to bring a social studies aspect into the unit to motivate the study of science. Logically less is covered due to the approach, but actually it is probably better to focus on how much the students recall and understand rather than what they were expected to by the teachers.. Less may really be more in their case. Some traditionalists claim that students who learn science via the S-STS curriculum unit fail to see the relationship between what they are learning and how it interacts with all the other aspects of the subject not used in the specific example used to motivate learning a given concept. For instance, the relationship between the oxygen context in water and its temperature is the theme of a famous unit in the ChemCom curriculum. Do the students understand that this phenomenon is important well beyond explaining why the fish in the river suddenly start dying? The issue that is the unit focus is so striking that it may make it harder to

generalize the concepts on the findings. 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 of the same science content and typically a teacher can't have that. They have to choose one. Does one choose what works best for the teacher and the majority of the potential science stars, or what works best for the majority of the class? We look forward to the day when on line support systems are readily available for the students not well served by the teachers decision.

Former WPI's IQP project groups have worked with various public school systems some used very hands on approach and others the STS approach. They have sometimes taken over classes, other times worked directly with teachers, while others have assisted behind the scenes developing curricula. Those assisting sometimes do so openly in class, running labs but never appear in class. Both types of assistance often involve analysis comparing student results from students of different types on day performance. Some teams are on deep background research looking at MBTI and MCAS scores. Hence, both directly and indirectly, teachers and students have provided feedback on what would be a good curriculum for the class or themselves personally. Rarely do they report directly what their experiences with the test curriculum were. In this sense our project will be unusual, we will survey test subjects directly.

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 out 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 abstract fashion are the focus of our concern.

The end goal of linking MBTI learner types with their experience of 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 be a considerable benefit to middle and high schools students since we expect it to help the various types of learners retain the more of the conceptual and factual knowledge they are exposed to during their educational experience. The MCAS is an accountability test that was designed to ensure that students have learned at least the bare minimum from their educational institution to be literate at a 10^{th} grade level, before receiving a high school diploma. Even though "Advanced" scores are acknowledged by state colleges and universities when offering scholarships to support a student's continuation with education, the great concern for students who might fail the MCAS due to handicaps based on their learning style and never be admissible to a college at all. If different learning styles call for different teaching approaches, schools should be obligated to produce a program to accommodate all types/ Ideally one wants an equal opportunity for all student to succeed in their classes, but at least they should be able to pass the graduation test.. No one can equalize the odds of doing really well on

this test, but no one should be handicapped so much that they can't pass it, due to learning style mismatches.

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. In theory, any of these curriculum units could be used for the stimulus our study. A short description of each unit is offered below:

"The Sun and Earth and NASA" which has been already successfully tested at the Downing Street school in Worcester, MA. It originally was STS only in the first half and drifted back towards more of a traditionally taught unit, with standard organization in the second half. It could be revised to become a more complete S-STS format and some steps were taken in that direction. 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 second generation version of the first unit developed at WPI. This unit is particularly interesting because it is able to have role playing game 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]

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

Third, "Medieval Technology: an Arms Race?" This physics unit was also tested at Greendale elementary school inspired by a partnership between Greendale and the nearby Higgins Armory Museum, but oddly enough not using that major resource directly. Teachers of the classes have given it positive feedback. It 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 Somerville school system in Massachusetts for use by a music teacher, 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.

Lastly, the unit called "Light, Lasers and the Eye: an S-STS Unit" which was originally tested in 6th 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 a technology vs. safety debate can come close to home. [5] On the other hand, the science is all over the place, in term of the subjects covered, ranging from Anatomy to Physics.

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