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Developing an STS Curriculum Using Robotics as a Topic

in cooperation with
Doherty High School
Worcester, Massachusetts

A Interactive Qualifying Project

Submitted to the Faculty

of the

WORCETER POLYTECHNIC INSTITUTE

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Bachelor of Science Degree

By

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Abstract

This project involves the designing of a curriculum unit that utilizes history and social context, along with group work, to teach robotic lessons at Doherty High School in Worcester. The groups were formed by using a cognitive styles test. Previous Interactive Qualifying Projects were used as a stepping-stone to the development of our STS curriculum. It is anticipated that the students will benefit from this style of teaching, because it relates science and technology topics to social situations, which should aid in understanding. Also, we are hopeful that the topic of robotics is as enjoyable and interesting as we feel it is.

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Mr. Candito's 5th period class

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Our Families

Our Friends

&

Worcester Polytechnic Institute

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1 Introduction

1.1 Focus

The goal of this project is to develop a curriculum to be part of strand 3 of the Massachusetts Science Curriculum, which relates directly to the technological design aspects of a science education. We agree with Technology Educators Association of Massachusetts (TEAM) that the traditional science curriculum does not provide the student with enough knowledge to understand basic systems, such as electrical and mechanical processes and infrastructures upon which our civilization is dependent. These processes involve design, application and production, all aspects of technology that are the framework of a technological society. A science curriculum that does not require the student to apply knowledge to be able to devise a plan, design the product, gather the appropriate materials and suggest methods of manufacture is lacking part of the training necessary to produce technologically literate citizens of a technological society.

We also understand that Massachusetts has presently accepted a test known as Massachusetts Comprehensive Assessment System (MCAS) to assess whether the students are prepared to receive their high school diploma. This test is administered in 8th and 10th grade. One/fourth of the science test contains information that deals directly with technology aspects of the curriculum. Some of the aspects that it touches upon are design and manufacturing. Our unit of the curriculum will be heavily based on these two issues. That should give our students boost on this part of the MCAS examination, when they take it.

Since the traditional science curriculum is heavy on theory and short on application we are interested in helping to balance it, as TEAM suggests, with attention to design issues. We feel practical application or a "hands-on" method of teaching is more effective in teaching both science and technology especially where design and materials issues are considered. In addition to involving some manipulation of materials, our ideal curriculum unit would also be socially connected. Social context is important to make the technical subjects "relevant". In this case we think it should be easy to teach some of the history of technology as well - and possibly connect with the Social Studies curriculum.

Our original idea was to use telegraph as a subject to teach the students about the process of technological development. Building a crude replica of an early model of a crystal radio, telegraph or electric motor is a good way to get at the basic content behind radio waves, magnetism, electric fields, and so forth. Before the devices were polished and the components miniaturized, they were big enough to handle and fairly easy to understand. We understand that Derek de Solla Price was interested in the early days of the telephone, and gathered predictions that were made about the social impact of the (then still expensive) telephone. However, the move from telegraph to telephone was as powerful an event as the emergence of Internet on top of the telephone already in existence. The idea of telegraph was not accepted by the Worcester public schools, however the teachers we met were interested in the communication principles that were used by early telegraphs. We hope that the idea of the telegraph will be used in the future because it has a rich background that is needed to understand present communication systems, including the communication between robots and the world.

We also want to take the issue of teamwork in designing technology seriously and study how students with different cognitive styles approach and solve problems while teaching about cognitive diversity as it affects group dynamics. In order to study this aspect of teamwork we will divide the students into four different groups by using Gordon's cognitive styles typology. This typology breaks up the students into four cognitive types called integrators, problem finders or assessors, problem solvers and implementors.

The different cognitive (learning) styles represent different strengths. One type has strength in open-ended problem solving. Another type is most comfortable with structured problem solving. The third type can do either and are at their best handling a combination of open-ended problems with complex materials but prefer more structured problems, and the last type is highly efficient in solving problems by logical extrapolation and can also succeed in trial and error approaches due to their persistence. The curriculum that we hope to design will be developed so that all the four groups will each get to employ their strengths and develop their preferred problem solving skills working with someone who is more comfortable in that mode. We also hope that it will stimulate the average student's understanding and interest in technological sciences.

Each type flourishes, compared to the other, in a different "task environment" which varies from structured to open ended and involves the handling of complex straightforward concepts and factual materials. One can group them in cognitively diverse or homogeneous teams, the diverse are more likely to experience conflict, but also to produce quality work with innovative approaches. The homogenous groups need to be well suited (matched) to the task to perform at the same level, but the team members typically get along well and communicate effectively.

Our goal is partially educational-but also educational research-so the first step is to demonstrate the impact of cognitive differences. The students will be given an object that is a common electrical and mechanical device, but not in its existing state. This object will be comparable to its crude earlier-possibly original-form, prior to the improvements already made by past development teams over the years. Their task is to improve on the given model, and see how the type different groups go about "brainstorming". Reformation into type-alike teams to actually work up a proposal and plan is also under consideration. Then all the type-different teams could work on the same problem.

In order for the students to be able to complete these projects they will need to understand the basic concepts and processes of each relevant technology. We plan to develop a set of lessons that will help students progress easily through each part of the project that we want them to carry out. These lessons will consist of specific sections, where each would be aimed at a specific part of the project. One lesson that we devised was to describe an abstract system like electricity, by comparing it to a system that uses water and pipes. The pipes would represent the wires and the water would represent electrons. Hence, the flow of the water would represent current, and changing the diameter of the pipes would be the resistance. This is an instance of using technology to make science concepts more tangible. However, this is just the beginning, we want to make science relevant and important to everyday life via technological application, then increase student understanding of technology which we think will grow as well as their interest does. If we achieve success in teaching the students about technology, then the students will be more eager to learn other concepts that formerly may have been hard for them to grasp.

When students know how things work and use that information in a design, they will better understand the entire concept. If students are taught straight from a book with no practical applications then they will have difficulty retaining the information and when problems arise that do not "fit the mold" they will find that they did not fully understand the concept. This is especially true of certain type of learners. Nothing in technology can be described by using one standard formula so being able to apply knowledge when the conditions are not ideal is the best test of one's level of understanding.

1.2 Overview

Our Plan is to use the subject of Robotics to teach the student technological information that will be useful in aiding them to join the technologically literate part of our society. In order for us to combine all of the parts into one unit we will use a model that can be found in Figure 1. The first part is to administer the cognitive styles indicator, which can be found in Appendix A. After the administration of the measure is completed we will lecture the students briefly about the history of the robot and the social implantation that robotics brought into our society. Following exposure to the social context, the students will be divided into their appropriate cognitive style groups. While in groups we will run a few activities on learning the functions of the robots try to convey the fact that robots have many limitations. These activities will also help the students understand that robots do not have brains and the programmers (in this case the students) are responsible for writing the logic (brain functions) that will control the robots.
The next important part is building the prototype robot. The building of the robot will coincide with learning the key core concepts. Instead of teaching the concepts first and then having the students implement a project, we felt that once the students saw how

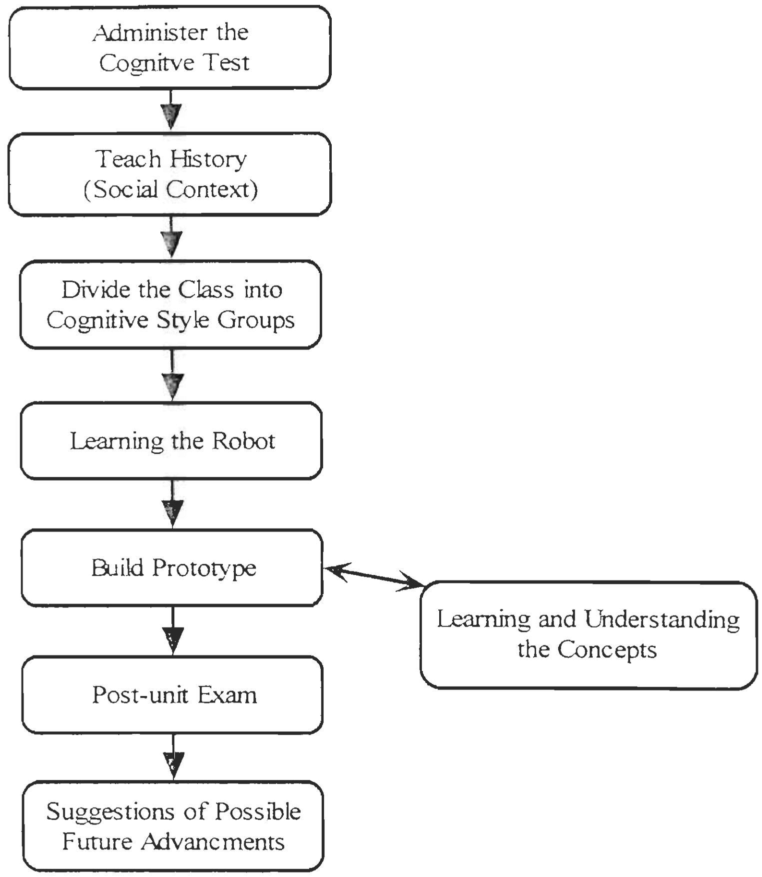

Figure 1: Model of the Unit

it works they will be more interested in the theory behind the product. Following the building of the prototype and learning the concepts we will administer a post-unit exam that will bring together their knowledge of the concepts, design, and manufacturing. Part of this exam will also ask the students to suggest ways that the robot can be changed to implement other tasks in different environments. We feel that if the student understands this Robotics idea, the student will be able address this "out of the mold" question and come up with very interesting designs and implementations.

1.3 Our Background

Our initial idea to design a curriculum unit for Worcester Public Schools came from a high school that we attended. Cranston High School West and Cranston Area Carrier and Technical Center in Cranston, Rhode Island offers a very unique program that we felt would be an ideal curriculum unit that Worcester Public Schools can teach to educate their students in the field of technology.

The program that we attended was Robotics and Automated systems/Pre-Engineering. This is a three-year program that is structured around the current technological advancements. The program includes the following topics:

- Robot structure
- Robot programming
- Digital Electronics and Analog Electronic
- Fiber Optics
- Lasers

The same teacher teaches the three-year program all three years (Mr. Spidell B.S.E.E, M.S.M.E)

The way the program taught is during the first year the students are faced with 75% theory and 25% hands-on experience. The second year the students work on small-scale projects that are 50% theory and 50% hands-on. Third year the class as a whole is responsible in a design and implementation of a major project. This last project is broken up into 75% hands-on and 25% theory. Some of the projects that were designed and implemented by past classes are:

- Underwater Remotely Piloted Vehicle (RPV) with wireless video transmission system.
- Vehicle with vision and speech recognition that is used to deliver mail within a factory setting
- Test and Calibration Equipment

These projects are extremely difficult and require a 2-year preparation period.

In designing our unit on robotics we wanted to use a similar teaching approach, where the concept would be taught along with the implementation and design. However, we knew that the facilities and the time devoted to technology for students like us-in the college preparatory track of the main high school is highly unusual. What can be done in a single course with little equipment beyond that available to a high school shop teacher and what could be found in the local toy store? We feel that we were stimulated to learn theory because we wanted to come up with a better way to implement a problem, and having the knowledge of theory we could come up with a better way. The unit will be based on a pick and place robot, which is a simple robot structure. The Robotics theme was actually not our idea. The technology teacher at the sponsoring school had been thinking about such a unit for a year and ordered many of the necessary materials. It was serendipity that his initial steps combined so well with our background. We would use some of the technique that we learned in Robotics and Automation Systems, along with our idea of the curriculum to design a unit on robotics using simple materials available to any high school teacher.

2 Literature Review

2.1 *Cognitive Styles*

The science of cognitive styles took shape during the 1960's. Interest in creative ability was something that people were trying to measure. Some tests had been developed to test creativity but they only focused on problem solving and did not deal with the problem formulation aspect of the creative process.

Gordon realized this and he accidentally developed a test that did not correlate with other "creativity" indicators, but was predictive of who was getting contracts and patents in industrial science. (Gordon and Morse, 1969) He looked closer and found that the existing measures typically got at who solved given problems and his got at who was coming up with promising ideas and formulating the problems in a useful way. Gordon formulated his insight into a test that he called the "Differentiation" measure. He combined his measure with a second section called Remote Association or RA, to produce a cognitive style indicator. This RA section a controversial indicator of creativity, because there are right and wrong answers involved, was developed by Mednick. Typically creativity measures measured the flow of ideas and did not judge the quality of the responses. Creativity was thought to be divergent rather than convergent thinking, so having a test with right and wrong answers did not make sense to most contemporary psychologists. However, Mednick explained that the RA portion of the test was divergent in the fact that one must think of a number of different possible solutions to the question and then find the answer that fits the best. Hence, it had both divergent and convergent components.

2.1.1 The Four Style Groups

Prior to 1964, differentiation and RA had been used to predict performance of researchers in industrial research and development, but they were not used together, in the same study. Gordon and Morse created four groups based on the different ranges that can occur from the test scores. These four groups are shown below:

Differentiation	Remote Association	Type
High	High	Integrator
High	Low	Problem Finder
Low	High	Problem Solver
Low	Low	Implementer

These four cognitive styles could now be used in predicting how certain people will perform in certain task situations. A person who scores high on differentiation is generally someone who perceives things in parts. They are usually aware of subtle changes and also have an eye for detail. While on the other hand, a low differentiation scorer sees things as a whole. They do not get hung up on details; however, they can overlook the unknown or unexpected.

2.1.2 Relations to Different Disciplines

There have been studies that undertake to see if there is a correlation between one's cognitive style and one's area of expertise. J.M. Wilkes completed this career choice study in 1976, with a sample of 194 academic scientists from four fields: Physics, Chemistry, Economics, and Sociology. From the data that was collected there are a few observations that one could make. First off 42% of the Chemists that took the test proved to be in the Problem Solver group, and 35% of the Economists scored in the Implementer group. There was also a number of problem solvers concentrated in the Econometrics and Public Finance specialties. Both of these groups are low on differentiation, so one can see that in these areas of science one can function without that quality. Note that they have relatively mature theory to structure the research.

As for the people that scored high on the differentiation section, 39% of the Physicists were Integrators and 32% of people in Sociology were Problem Finders. These two areas of science were relatively strongly impacted by theoretical turmoil at the time, definitely areas where an eye for detail is helpful. Having an ability to perceive things by their parts can be an advantage in these disciplines.

These four different areas represent the different types of scientific minds that will be present in a class. When the students are split into type-different groups, some of the groups will be better suited for the design project presented to them. Our curriculum design has qualities similar to a Physics discipline, so it could be expected that the Integrators and the Problem Finders will be better adapted to excel.

All of the above factors will be used in our project. The students will be aware of their cognitive style and they will be in groups with people who are not of the same type (learning style) as they are. By administering the GCSI to these students we can use it to predict how each student will do in the class and hopefully our project will be one where all the learning styles can benefit and learn from each other.

2.2 History of Robotics

Robotics is not as a new area of science and technology, as you might think. Autonomous systems, precursors of various types, have been around for centuries, but not until the 1900's did the use of robotics expand to areas like factories, medicine, and domestic homes. Robotics, along with many other technical fields, advanced greatly in the 20th century.

Many of the first images of robots were based from early science fiction books and movies. These robots were machines created in the shape of humans that could act and think under its own power. This robotic technology is an android with what is called artificial intelligence or AI. A robot of this fashion is not presently practical or realizable, but this is the model where the future of robotic technology is headed.

2.2.1 History and Social Context

The use of robots and automatons has been around for thousands of years. Egyptians used lever action dogs in their tombs, to perhaps scare off potential looters. Then in the Middle Ages, the clockworks of the town clocks were used to move figurines to ring a bell. By the 14th century a mechanical rooster had been built onto of a church and it would crow and flap its wings every hour. These three examples illustrate that the idea of mechanical servants have been around for many years and that they were also used in many facets of life.

It is believed that there are a couple of origins to the word "robot". One of the more popular and earliest is the word "robota" which is Czechoslovakian. This word means forced labor and aligns itself with the ideas of robots. Robots do not have free will, human programmers command them and they follow and complete the orders.

Many feel that this word "robota" has evolved into the word robot that we used today. However, the word robot did not appear in print until a 1921 play written by Karel Capek. The play was called *R.U.R.* or *Rossum's Universal Robot*. The plot of this play centered on a man who invented a robot, and at the end of the play the robot turns on its creator and kills him. This play is obviously science fiction because a robot with artificial intelligence in not realizable today, never mind in the 1920's. But that is not the most important factor of the play. The fact that the robot eventually turns on its master and kills him represents the social attitude toward robots at this time.

Many other books and plays that were written at this time also illustrated robots in a negative and unflattering light. Even when movies started to become popular, evil robots were shown causing harm to humans. For example, in Fritz Lang's *Metropolis,* there was an evil robot named Maria that wanted to punish all of humanity.

All of these mediums represented the way society had felt about robots. During the early 1920's, the American people's interest in science was on a comparatively smaller scale than that of mechanical servitude or automatons. There was a free and fun attitude toward life at this time and the great number of robotic uses was not being explored at this time. Also, soon after this period came the Great Depression. During the Depression about 25% of the American population was unemployed, so there was little thought about a robot that could build cars or help with the housework. Labor was cheap and jobs were needed. Because of these attitudes, robotics did not interest many people during this period. No one was buying anyway.

This attitude remained prevalent for a while, until around the 1950's. In 1950, Isaac Asimov wrote a book called *I, Robot.* In this book he told of futuristic tales where robots were helpful to humans. Asimov predicted that there would soon be a robotic revolution where the full potential of robots would be realized. He also coined the word "robotics" and created a list of three laws that would govern the roles of robots. Asimov's Three Laws of Robotics are as follows:

> **First Law** - A robot may not injure a human being, or, through inaction, allow a human being to come to harm.
>
> **Second Law** - A robot must obey the orders given it by human beings, except where such orders would conflict with the First Law.
>
> **Third Law** - A robot must protect its own existence, except where such protection would conflict with the First or Second Law.

These three laws were followed in each of his stories and through this reasoning changed many people's attitudes towards robotics. Also, the robots in his stories were depicted in productive and helpful ways.

Soon there were industrial companies that were using robots in their factories. In 1956 George Devol and Joseph Engelberger developed the first robotic company to produce the robots that would work in factories. Then in 1961, the General Motors factory in New Jersey began using robots in order to assist in the production of their automobiles. This practice soon expanded, especially in Japan, where there was a labor shortage, and today there are a great number of automobile factories that use robots, and a lot of other industrial companies use robots as well.

During this period there was a change in the social attitude toward robotics. Many people were interested in the ways of science and technology, because the newly explored area of space captivated so many people. Robotic technology was used on the various space missions and Hollywood massively expanded on that to illustrate the possibilities in this field. Some of the space uses, and more the Disneyland and Hollywood simulations translated into robotic uses for the home. Many people were looking forward to the future and imagining how robotics could be used to make their lives easier. For the first time people were contemplating a robot that could help with the housework, or mow the lawn, or drive your car. Also during this time, the economy was getting better and financially people were living more comfortably than they were during the Depression.

This change in attitude is evident in the movies and television shows of the time. Star Trek and Lost in Space are good examples of this. In Star Trek there is an android with artificial intelligence that helps the crew, and the same is true for Lost in Space. Star Wars and Short Circuit are also examples of movies where robots help humans. Not all of these movies show robots in a positive way, but it does show that people can think of robots as useful and productive.

From the beginning of the 20th century to the close of it, society's feelings towards robotics have taking a 180-degree turn. Many people are excited about the future of robotics and the possibility of artificial intelligence. There are an infinite number of possibilities in the area of robotics and designers, companies, and the government are all ready to explore those possibilities.

2.3 Telegraph

As previously mentioned the telegraph was the initial idea that we were going to utilize in order to teach technological advancements to the students. The telegraph is a very important aspect of the history of technological advancement. Even though many people today do not associate telegraph as a modern tool, many of the principals that were used in telegraph are used in today's communication devices such as computers. The telegraph had a major impact on the people in technology and how they communicated. Communication is a crucial part in many other fields of technology, including robotics, as shown in part 3.3.4.

The telegraph went through many changes and even though it started as a flash card (will be further discussed in the next section), the telegraph has evolved into the present day telephone. The telegraph to telephone evolvement is extremely interesting to look at and see how it affected our society. One can also follow the changes from telegraph to telephone to robotics/automated systems. Robotics, like the telegraph, also started as a very simple design to help perform simple tasks and now has flourished to perform functions that are repetitive, hazardous, or require precise accuracy, beyond the reliable use of human hands dealing with small objects.

2.3.1 History of Telegraph

> On April Day in 1746 at the grand convent of the Carthusians in Paris, about two hundred monks arranged themselves in a long, snaking line. Each monk held one end of a twenty-five-foot iron wire in each hand, connecting him to his neighbor on either side. Together, the monks and their connecting wires formed a line over a mile long.
>
> Once the line was complete, the abbe Jean-Antoine Nollet, a noted French scientist, took a primitive electrical battery and, without warning, connected it to the line of monks-giving all of them a powerful electric shock.
>
> Nollet did not go around zapping monks with static electricity for fun; his experiment had a serious scientific objective. Like many scientist of the time, he was measuring the properties of electricity to find out how far it could be transmitted along wires and how fast it traveled. The simultaneous exclamation and contortions of a mile-long line of monks revealed that electricity could be transmitted over a great distance; and as far as Nollet could tell, it covered that distance instantaneously. (Standage, 1999)

Nollet was not making many friends among the monks. However, he did open up a new era for research in the field of communication. Since Nollet demonstrated that electricity travels "instantaneously" the scientists believed that they could use this knowledge to build a device that can transmit messages "instantaneously" over great distances. This was the first great push towards the telegraph.

The electricity experiments started the interest in high-speed communication but the early telegraph did not use electricity as part of its communication source. The monks designed the very first telegraph using a piece of cardboard that had a white and a black side (know today as a one bit system). Since this one bit system was limited to very few options, they quickly expanded the system to six pieces of cardboard (a six bit system), which gave them 64 different combinations that can be used to transmit information.

The six-bit system became popular because it could transmit the entire alphabet, number set, and more. Even though a 6-bit system can transmit all the information needed to be able to send a full message it still had many problems. The first problem that the system had was its need for line of sight. Line of sight was fixed by setting up the telegraph apparatus on the highest hills, often known presently as Telegraph Hills. The second problem that the telegraph had was the condition of the weather affected the transmission of the telegraph. Unfortunately, the weather could not be controlled. Since the apparatus had so many different combinations the citizens needed professional people to run this kind of telegraph. The access of an ordinary person to the telegraph was very limited. The messages that could be sent over this telegraph system were limited in size and very expensive. It was hard to send long messages over this system because the operator needed time to set up each letter, signal that it is ready, and ensure that the other side received it.

All these problems with the six-bit telegraph led scientist on a venture to design a telegraph using electricity. The initial step towards the electric telegraph was a design that incorporated magnetism with electricity. This device functioned by a needle that would move to an appropriate letter by adjusting the magnitude of the voltage. This change in voltage will adjust the magnetic field and move the needle to the appropriate letter. The idea of the device was excellent, however it was not practical because the device could only transmit 20 letters and it required 5 different wires. This design was a combined effort of William Fothergill Cooke and Professor Charles Wheatstone.

		U	* * _
A	* -	V	* * * _
B	- * * *	W	* _ _
C	* * *	X	* _ * *
D	- * *	Y	* * * *
E	*	Z	* * * *
F	* _ *		
G	- - *	1	* _ _ *
H	* * * *	2	* * _ * *
I	* *	3	* * * _ *
J	- * - *	4	* * * * _
K	- * -	5	_ _ _
L	----	6	* * * * * *
M	- -	7	_ _ * *
N	- *	8	_ * * * *
O	* *	9	_ * * _
P	* * * * *	0	------
Q	* * _ *		
R	* * *	Period	* * _ _ * *
S	* * *	Comma	* _ * _
T	-	Question	_ * * _ *

Figure 2: Morse Code

Concurrently as Cooke and Wheaton were designing their version of the telegraph Samuel Morse was working hard on designing another version of the electric telegraph. Even though Samuel Morse is considered "father of the telegraph", his first major contribution was Morse code, which can be found in figure 2. The device that Morse used implemented a scrolling tape that would be marked with an appropriate transmitted sequence. This sequence can be translated by anyone that has a translation key. The translation key can be seen in figure 2.

The new electrical system eliminated all of the problems that the previous systems had. Problems such as line of sight and weather were no longer an issue. Because of his code, Samuel Morse became known as "father of the telegraph", even though he did not actually invent the hardware for the telegraph.

In 1849 Morse was granted a patent for the printing telegraph that he had been developing along with his colleagues. The telegraph was such a great success in the United States that telegraph lines were spreading across the world The telegraph revolution was so powerful that within 5 years of obtaining a patent, the telegraph covered 23,000 miles, and quickly became the primary mean of communicating. (Standage, 1999)

2.3.2 Social Context

The era before the telegraph had great difficulties with distance communication. The only form of communication in use was the mail system. The mail system was slow and there was no assurance that the letter would arrive at the final destination. The poor means of alternate communication limited citizens to communicating within their own city limits. Only the mail system had reach over distance unless a special courier was available.

With the new development of the telegraph the information and news traveled much more quickly. The Residents of the city were not just communicating with other residents within the city but also outside of the city. The information that was transmitted was accurate and delivered to the recipient almost instantaneously. In mid 1800's, the telegraph was still a brand new invention and could only transmit over short ranges, again limiting the communication range to the neighboring cities. However, the news could be passed along. At first, this was a huge draw back to the apparatus, but as the technology matured the systems became more sophisticated and could transmit longer distances. As a result, the communication industry was hitting a high peak.

The communication industry (telegraph, mail, and railroads) was uniting the nation from small cities to major metropolitan areas. The telegraph started evolving from a dream to a reality that was accessible to everyday lifestyle. Now this great invention was available and people were using the telegraph for pleasure and business.

The telegraph still had some major drawbacks. One concern was people could not have the telegraph available at their house. If they had to send or receive a message they had to go through a telegraph post. Another difficulty was the telegraph still required people to be able to encode and decode the messages to be sent over the telegraph, which was a costly barrier to sending a telegram. Scientists and engineers began working on these concerns and tried to figure out a way that people would have communication devices at their disposal at home, and to be able to communicate without using codes.

2.3.3 Telegraph to Telephone and the Relationship to Robotics

As the telegraph was becoming more popular, it seemed like there could not be anything better for communication. The people that invented the telegraph never imagined an invention that could overshadow the telegraph. The telegraph at that point seemed like the ultimate form of communication, however there were still drawbacks (explained earlier) of having the telegraph as the primary form of communication. What could possibly be even better than having a device that transmits messages?

From 1849, when the patent for the telegraph was granted, until 1876 the telegraph was the only source of electrical communication. Citizens did not recognize the telegraph was already past its heyday. Scientists and inventors such as Edison, Watson, Hughes, and many others were looking for a way to transmit good quality sound over long distances. In 1876, the telephone was introduced and took everyone by surprise. Bell was only trying to multiplex the telegraph so that it could carry more messages over the same line - different ones at different tonal levels. At first no one was expecting the telephone to replace the telegraph, certainly not as fast as the transition happened. Ten years after the telephone was invented there were quarter of a million units in use and by 1900 there were two million phones in service. That is nearly one telephone for every ten houses. (Standage, 1999) The telegraph faded away quickly, and the telephone became the device for the new century.

The transition from telephone to telegraph had a huge impact on people. The problems that were associated with the telegraph disappeared. The telephone can be used by anyone and does not require key codes and the need for people to translate them. People were no longer communicating just within their country, they were communicating with the whole world. The new era of telecommunications opened up doors for many new opportunities both socially and economically. In less than a century, the communication industry went from having no form of technological communication, to communication with flash cards, to a more sophisticated device that scientists called telegraph, and lastly to telecommunications. Over the years the telephone has undergone many changes and has become the primary form of communication.

It is hard to see at first how the telegraph and the transition of the telegraph to telephone is relevant to Robotics. We did not intend to study the two subjects back to back, but in considering them as an alternative thematic for an educational program we saw several connections. The foundation of communication is based on the telegraph and Robots use a form of communication that the telegraph used in its early days. Most robots are logically programmed with a sequence of instructions. These instructions are very similar to the instruction set that was sent over the telegraph. The pulses and dashes that the telegraph uses are similar to logic high's (1) and logic low's (0) that the robot uses for their instructions. By combining a sequence of 0's and 1's one can send this information to the robot control panel and the robot will function to that instruction set. The telegraph provided the foundation for modern communication technologies such as robotics and Internet.

In examining the transition of telegraph to telephone we saw how advancements were made and how problems were solved. The robots were initially designed to perform three functions. These three functions were:

- Repetitive work
- Hazardous work
- Work that required accuracy beyond hand-eye coordination tolerances

The robots started out as simple pick and place robots, just like the telegraph started out as a simple message transmitting apparatus. We saw that the telegraph gradually became more advanced and ultimately became the telephone. The robotics is also moving through patterns of incremental development. Today's robots are no longer limited to pick and place robots. The Robots that are available today can perform analysis and contain many senses that human possess, such as vision, touch, and hearing. Robotics is just hitting the beginning of its development curve where the future presents the possibility of an artificial intelligence system merger of robotic capabilities with "mobile" sensing and processing power will bring robotics into its own. The artificial intelligence idea may now seem unfathomable, but we must remember that in the age of the telegraph so did the telephone, yet it was only a step away.

2.4 MCAS

MCAS, or the Massachusetts Comprehensive Assessment System, is a statewide test that all 10th grade Massachusetts students must pass in order to graduate. If students do not pass the test the first time around they can try again during their junior and senior years. The state of Massachusetts hopes that this test will raise the level of learning in its high schools, but making schools and individuals accountable.

The first "high stakes" testing occurred in the school year of 1999-2000, and the students that were sophomores then were tested before for practice when they were eighth graders. Two other prior classes took the test to establish benchmarks and gain experience with logistics and various particular items. This pre-test was done so that the state and each community could get a small hint as to the number of students that will pass the test, when they take it for real. From this pre-test the eighth graders in the city of Worcester, did better than most other cities, but did not score very well compared to the rest of the state of Massachusetts as a whole. In 1999, among 10th graders and in the state as a whole 40 percent failed in math and 45 percent in science. In Worcester, 57 percent failed in math and 66 percent in science. Because of this relatively poor showing the city of Worcester is concerned about MCAS test. In order to attempt to improve the scores when the sophomores take the test, they have published a set of guidelines for the schools to follow. We also used these guidelines when created our robotics curriculum since technology, especially design issues, will be 25 percent of the science portion of the test..

The city of Worcester's guidelines were organized in a set of four strands; corresponding to the state's four strands, however, the fourth strand science, technology and human affairs is going to be eliminated by the state and actually moved to social studies. We are referred to strand 3, "technology and Society" guidelines while writing our curriculum, and we used the fact that the MCAS test contains areas of technology, especially design and manufacturing to justify the unit to our sponsor. We hoped that by writing a curriculum that followed along with the state and city guidelines then we would a better chance of being able to implement the curriculum at Doherty High School.

Another factor that we believed that would help us get a chance to implement our lesson plans was that we also attempted to create a curriculum that was aligned with the views of TEAM. TEAM, or Technology Educators Association of Massachusetts, is a group of teachers that believes that the traditional science curriculum does not provide the students with an understanding of basic technical systems. They feel like there is not enough design, production, or application subjects covered by schools today. Alan Kubicki is a member of TEAM and he is also a teacher at Doherty High School. Kubicki was our first contact at the high school and he directed us a colleague that would be willing to allow us to teach our robotic lessons, in the context of his class.

We played to the fact that many of the schools in the state of Massachusetts are worried about the science and math portions of the MCAS test writing our lesson plans and to increase the chance of being able to implement it. However, it really wasn't hard to do. since we are products of an educational program that did address the issue and we agree with TEAM, in that students today are not being fully prepared for the technology oriented world of tomorrow. They fought to get a portion of the test to make their concern and issue all over the state. Now they have to produce curricula to address that problem and we were glad that we could help. A student will understand a subject more if they can design and manufacture a product within the lesson plans. We feel that this ability gives the students a better comprehension and understanding of science and technology, as well as a good preparation for a scientific future. The question was how to teach the kind of things we were taught in the facilities of a vocational school without those facilities available, using just a normal high school shop program's basic tool and equipment set up?

2.5 Previous Projects

To develop a better curriculum we felt that it would be a great benefit to analyze projects previously completed by WPI students on Science, Technology, and Society (STS) topics. Although the previous projects did not deal with Robotics, or have design goals, we felt that some projects did a wonderful job creating a curriculum and developing lesson plans that raised technology and society issues and set the stage for "design" education. We will look at two projects that were completed before us. The first project is "The Quabbin Story", written by Jeffrey R. Modderno and Bob Tonning. This project did an exceptional job setting up lesson plans. The second project that we looked at was the Evaluation of the WPI Sixth Grade STS Initiative by Maria Salvati. This project focused on the problems that 10 prior project teams from WPI faced on the development of the STS curriculum projects and ways to make the projects better given the upcoming MCAS "crisis". Using the experiences and results of other projects we will develop our curriculum.

2.5.1 The Quabbin Story

Jeffrey R. Moddemo and Bob Tonning developed "The Quabbin Story" project. The Quabbin is a man-made reservoir that supplies fresh water to Boston Metropolitan Area. In order to create this reservoir four towns in Massachusetts had to be leveled and inundated. The destruction of the towns, to create the reservoir, created a thirty-year controversy before the project took place. The goal of Moddemo and Tonning was to develop a curriculum that would teach the students about the tradeoffs-especially the social and environmental impact of the Quabbin Reservoir, while teaching the students lessons in math and science via the history of the engineering project itself and its social studies through "case-study" analysis. (Moddemo and Tonning 1995)

The science through Science, Technology and Society (S-STS) method of teaching inspired Moddemo and Tonning to design this curriculum based on a perfect STS scenario that dealt with the Quabbin reservoir. The reason that this scenario was perfect is because it dealt with all aspect of S-STS such as history (social impact and historical background), science, and technology (water quality, aqueduct construction, dam construction, and pH). The curriculum that they developed included a set of lessons that were very well constructed. The lesson set were actually broken up into 4 parts, the parts are:

1. Lesson Template (Developed by Brian Keagle and Yianni Syrigos. Sample template can be found in figure 3)

2. In Class Activities

3. Visual Aids, Teaching Tools

4. Overall Lesson (Sample lesson can be found in Appendix D)

This four-way breakdown helped Modderno and Tonning organize lesson plans but they were not going to each class. They were "working for" Helen Poirier of Oakland Elementary School, a 5th and 6th grade teacher. Since the lesson plans were very well developed they can easily be implemented time and time again, and the units became one of her favorites.

Lesson Number	Topics for Discussion	Lesson Material	Student Responses/ Other teaching tools
1	General Overview of the Quabbin Project	Introductions, course goals and requirements, and Quabbin background.	Questionnaire
2	Boston's historic need for water.	History of water distr.. systems & their inevitable inadequacies	Part 1 of the "Quabbin" video; post-film discussions
3	The debate for a new water supply.	Present other options, steps taken before final decision was made (Talk about politics...)	Have the class decide for themselves the best possible solution to Boston's water prob.
4	How did the valley residents react to the fatal decision?	Present all aspects of story; break class into discussion groups	Role-playing exercise Vision of alternate future.
5	Preparation for construction, and construction	Cemetery, moving buildings, clearing land, Building of dam and dikes.	Library-reserve photos, Detailed discussion of technology used in dam/dike construction
6	Engineering Applications Basic math	Compare Quabbin capacity and dam fill to everyday objects. Introduction to basic Math (scientific Notation, conversion of unit)	Have students calculate various things through basic math
7	How does the water get from the reservoir to Boston?	-piping of water -Wachusett Reservoir -gravity feed	Calculations: -water speed -pressure -travel time

Figure 3: Lesson Template

Modderno and Tonning also came up with a pre and post questionnaire that they used to evaluate their Unit. These questionnaires can be found in Appendix B. We will use similar style of questionnaires to evaluate our results and judge the success of our project.

2.5.2 Evaluation of the WPI Sixth Grade STS Initiative

Maria Salvati's project involved evaluating the WPI STS projects and suggesting ways that future groups could have more success in getting it into use. She was making a case for STS curriculum materials. Although Salvati did her project evaluating the existing STS curriculum projects that were already done for the sixth grade, there were points that were useful in creating an STS unit for any grade level.

Salvati described three main goals (originally described in Syrigos and Keagle's) in developing an STS unit. The three main goals are:

- Preparing people to be citizens in a more technological society
- Making science relevant to the students' lives
- Motivating less-scientifically oriented students to continue to study science, thus preserving a range of future career options.

These goals set a framework in which the STS unit should be done, and it makes it easier to stay focused on the unit. The goal of developing an STS unit is to create technological literacy and help students become aware of the way science and technology affects their everyday lives. (Salvati, 1996)

"If the WPI STS curricula are to have an impact in the local public school, the units must meet the standards set by the state legislature", Salvati states. Even though Salvati was aiming that comment towards the *Science and Technology Curriculum*

Frameworks of Massachusetts, it is even more true today and given the MCAS test now administered in Massachusetts, to enforce that curriculum to the student. All the present STS units that are done today must be designed to cover information that will be on the MCAS examination if they were to get class time in the cities that are more threatened by the exam.

Salvati also left us a great deal of information on strategies and goals to develop an STS unit. She addressed the following items:

- Team Teaching
- Format and Organization of Units
- State Education Guidelines
- Field testing and evaluation
- Contacting local schools and teachers as "cosponsors" with WPI

In a team teaching environment it is important that there is more then one person involved in relaying the information to the students if you want expertise, but coordinating issues have presented a conflict to the WPI projects overtime. It is easier to coordinate the Social Studies and Science part of the unit if one person is teaching both, however, at the 9th grade level those teachers should be "specialist" who know and love their field. Hence, there is often a division of labor between English, Social Studies, Math, and Science who must be orchestrated to do a unit together. The second item that Maria covered was the state education guidelines. The curriculum must meet the standards that are set by the Board of Education in response from the state Department of Education. In practice each school district has a curriculum coordinator and Worcester has representatives for each academic field. These people now have authority over the curriculum and cannot be ignored if you want material to be used in the classroom. Field testing and evaluation was the next think that she talked about. The main goal of that item was the need to make contact early and to set the stage carefully in hopes to field-test that unit in the end. Coming up with a field site that will let you bring your teaching materials and work with you by teaching your unit is extremely difficult. If you don't teach it, it is not a good test of the curriculum itself and its transferability. The final item was the proper level of involvement of the advisor in the project. Part of the advisor involvement would be setting up meetings between WPI students and members of the public school system. Advisors must also maintain a database that would give new project groups advantage of knowing people on the "inside" of the school system, however oversight demands were growing. Students had a mixed reputation in the schools-criticized for not getting there and consulting enough with the teachers. The teachers had both logistical and lack of understanding of the system coming up as a problem. These are some of the important things that Salvati mentioned as part of creating a successful STS unit.

3 Curriculum Design

After meeting with our "host" teacher it became clear that in order to get access the topic would have to be robotics and we would have to teach the unit ourselves. He wanted to watch and he wanted us to help him use materials he had already acquired-a year earlier then he could have pulled things together on his own.

On reviewing the situation we decided that we could live with those constraints and not give up anything too important. The evaluation would be harder-but the teacher would be the main audience and he promised direct feedback. The ultimate question would be whether we'd produce something he could endorse to his colleagues at other schools.

The unit that we will design is a technological curriculum. The design of our program consists of four parts. These four parts are:

- Overview of the curriculum
- Assignments
- In-Class Activities
- Teaching Tools

Utilizing these parts we will design a curriculum that we hope will be enjoyable to the students and give them a good understanding of robotics and other technological fundamentals. In addition, these lessons will be taught by utilizing history and social context of robotics, in order to show the importance and pertinence of science and technology today.

3.1 Overview

The template below will show the basic overview of the curriculum unit. This template organizes the unit and illustrates what the unit will teach the students.

Lesson Number	Topics for Discussion	Lesson Material	Student Responses/ Other Teaching Tools
1	• Overview of the Unit • Introduction to Robotics • Cognitive Groups	Introductions and goals	Pre-Unit Questionnaire
2	• History • Social Context	Robots & Society Robots in Literature Evolution of Robots Future of Robotics	History Questionnaire
3	• Types of Robots • Robot Vocabulary • Uses of Robots • Robot Constraints • Where and When to use Robots	Where do we need Robots? Other possible uses for Robots	Game that demonstrates the constraints of robots
4	• Communications • THE XYZ	The definition of the XYZ axis Many forms of Communications	The Blind Role playing game The XYZ help to the blind game
5	• Power	Electrical Pneumatic and Hydraulic demonstration	Question and Answer Where and When to use which Power
6	• Logic • Boolean Algebra	Uses Gates Truth Tables Circuits that work	The Nuclear War Problem---Design Game
7	• Design	Each Group will get their own problem that they will have to deal with	They will want to do good because their design will critiqued by peers
8	• Design	The completion of design and answering questions does this satisfy the problem?	They will have to finish in 2 lessons; teaches time management
9	• Critique	Exchange of papers and peer critique	Development of group work
10	• Question and Answer • Instructors evaluations of Robots • Future of their Robot	We will answer questions that they have leftover and give them feedback about their work	Make sure concepts sunk in; Post-Questionnaire: Their view of how robots can be improved

3.2 Assignments

<u>Assignment 1:</u>

No assignment given.

<u>Assignment 2:</u>

Questionnaire; this will give feedback as to how the students feel about the historical lesson (Lesson 2).

In this questionnaire, what the students think about the history and the social context of the robotics will be addressed. In the future we hope that this project will be repeated, but instead to have the history section taught to the students after they have already learned about the technology aspect. Then compare the results from the different history questionnaires.

<u>Assignment 3:</u>

Have the students think of 2 applications of robotic use and then identify the specifications that the robot should have. Also, give two examples of first generation robots and description of each.

This exercise shows students the many different applications that are possible with robots. It also gives them a preparation for the design section of the lesson by devising specifications and descriptions.

<u>Assignment 4:</u>

Part 1: Students will be given a set of axis and they must plot a few points on the axis. Part 2: Students will be given a point and they must figure out the axis.

Knowing the X, Y, Z axes are an extremely important concept in robotics. Through the axis co-ordinate system the robot communicates to the world, and vice versa. To understand basic motions of the robot one must understand the three dimensional axes that the standard robots use for their work envelope.

Assignment 5:

For each power source give two applications and explain each supply's characteristics.

There are main key differences in having one power supply oppose to the other. Having the students complete this assignment will help them use the differences of the power supplies that they learned in the lesson to explain why it is better to use a specific supply in specific cases.

Assignment 6:

The students will have to solve a truth table for a given logic circuits.

Most of the electronic application that is used in robotics is based on digital technology. The digital technology is based on a simple principle of 1's and 0's or lows and highs. From this lesson the students will apply what they learned from the classroom about digital logic circuits and apply that knowledge to determine the output of basic logic circuits that contain logic gates.

Assignment 7:

No new assignment given, but they must finish their design by then end of lesson number 8.

Assignment 8:

Questionnaire on the problems that they encountered in their design, how did the students like working in a teamwork environment, and how much of the design was accomplished?

We will use this questionnaire to see how much the students enjoyed working in groups and what kind of problems arose within their group. The groups were designed to minimize conflict and simplify communication-but some of them should have an easier time with the assignment. We will use their responses along with their design to evaluate the students. We'd asses the project outcomes and test results separately and correlate them with the team survey report. The evaluation will be based on how much effort was invested into the project and on the creativity of design.

Assignment 9:

Write a paragraph on the future of robotics.

This assignment will make the students think out of the mold. If they understand the concepts they will be able to design a robot and utilize a lot of the concepts in different ways.

Assignment 10:

No assignment given

We hope these assignments will give the students practice outside the classroom that they will enjoy.

3.3 In-Class Activities

<u>Lesson 1:</u>

- Administer the Pre-Questionnaire
- Introduce The Unit
- Set up Cognitive groups
- Give them Objectives and goals

In order to be able to see if this curriculum, that we have planned, works, then we first need to know what knowledge of robotics the students may already have so that we don't take credit for robotic things they already knew. . We plan to do this with a pre-questionnaire. This will allow us to do a before and after analysis in order to evaluate our curriculum. The pre-test should only take about twenty to thirty minutes at most and the students will know that this test is only to tell us their knowledge of robotic science, so this way the students should not be discouraged if they do not know most of the answers.

After taking the pre-questionnaire the students will be aware of the subject material of the curriculum unit, but it is at this time that we will introduce the unit and what we hope to accomplish in the class. An explanation will be given about the two-week course and the main guidelines will be discussed.

Once the introduction is complete, the cognitive groups will be complied from the results of the cognitive styles test, the students completed prior to the class. There will be four groups and their classifications are explained in the literary review section of our report. The students will be working in these groups for the duration of the unit.

These groups will then be told the objectives of the course and also asked that they formulate goals for themselves and the groups. The students will also be aware of our goals and expectations.

Lesson 2:

- History
- To see how History affects Robotics
- Social Context
- Why Robotics
- Depending on who is teaching, the unit Ice Breaker, may be appropriate

A history on robots and robotics will be presented to the class. This history lesson will tell the social connection of robots, in the past as well as present, the mention of robot in early literature and plays, some examples of what the early robots could do, the progression of robotics throughout the 20th Century, and the predictions of the robots in the future. Many of these topics will involve class participation, because their perceptions of robots will be integral in the success of this unit.

After a broad overview of the history, there will be a more detailed look at the progression of robotics throughout the last 100 years. This again will be done through class participation and the students are encouraged to speculate about the likely evolution of robotics from this point forward. This is a good way to disprove any misconceptions about what we can do today.

Most of the changes in robotics that have occurred are mainly due to two factors. The first one is the need for new and more autonomous technology, while the second is the social perception of robots. The students will learn about how, in early America, many were afraid of robots and they were not accepted socially as an appropriate technological goal. The issues raised by idea of robots being present in the home and not just in factories or industrial settings will also be discussed.

After much of the teaching of the history on robotics students will be asked the question of why robotics? The students will be asked to think about the benefits and disadvantages of robotics and what they believe the future of robotics is.

Due to the fact that there are a lot of discussion aspects to this section of the unit, an icebreaker type game may be appropriate during this lesson in order to ensure that all will be encouraged to participate and express opinions.

Lesson 3:

- Types of Robots
- Robot Vocabulary
- Uses of Robots
- Robot Constraints
- Where and When to use Robots
- Work Envelope

During this lesson the students will learn about current robotics, rather than focusing on the history. The different types of robots will be taught and for this section illustrations will be used in order to give the students a better comprehension of the many different types and styles of robots.

In order to ensure that the students are able to follow along with this section of the unit, a separate section of robotic terms will be needed. These terms will be explained and a copy of the terms will be handed out to each student for him or her to study and learn from.

Students will now be asked for ideas of some possible uses of robots. This may bring forth specific answers, but the facilitator should encourage some broader applications in order to illustrate to the class the large number of uses of robots.

Another important aspect of robots that will be taught in this lesson is the work envelope of the robot, or its constraints. Each type or style of robot has a different work envelope that limits it actions, but each case has advantages over another constraint.

The activity of this lesson will have the students take part in a game that teaches them about the different work envelopes of different robots. They will be asked to imitate certain robotic functions and perform tasks with the same constraints that that particular robotic system is imposed with.

Robots are used all over the world and their use increases everyday. Knowledge of practical applications of robots will help the students in knowing when and where robots are being used.

Lesson 4:

- Basics of communications-Telegraph
- Robot Communications
- The Blind Role playing game
- The XYZ
- The Blind role playing game with XYZ

This lesson involves the students learning about the communications of robotics and computer communication as well. The students will first be introduced to a small history lesson that deals with the idea of the simple communication of the telegraph and how it evolved, then compare it to the computers of today.

The students will then be taught how a programmer must tell robots what to do, no matter how simple the task. In order to communicate with a robot, one must be very deliberate and specific, because that is how they work. In order to emphasize this point a game will be played.

The Blind Role playing game is where one student is blindfolded and another student will be the communicator. The blindfolded student will act as a robot and follow directions specifically and deliberately, while the communicator will attempted to command the blindfolded student to complete a task.

Upon completion of the game the students will be taught the idea of the XYZ coordinate system. The students will be shown how any point in space occupies a space that can be expressed in three measurements. Once this concept is learned the Blind Role playing game will be played once more.

This time during the game the communicator will be asked to only use movement commands that follow along with the XYZ coordinate system. After the completion of this round of the game the students will then be asked which version they thought was better. It will also be explained to the students that the second version is a major way to communicate with robots.

Lesson 5:

- Power
  - Electrical
  - Pneumatic
  - Hydraulic
- Where to use each power and why?
- Demonstration of power

The different types of robots were explained in an earlier lesson, but now in this lesson the different powering of the robots will be explained in more detail. The electrical robot will be illustrated through by showing the students electrical components and motors. The pneumatic robot will be explained with the help of syringes and demonstrations of the power of air. Syringes can also be used in the explanation of the hydraulic robots, as well as an illustration of the uses of liquid in this situation.

After the description of these three different types of power sources for robotic movement a discussion will occur where the pros and cons of each style is discussed. Each power type has its own specific conditions, as well as applications, and an understanding of them is essential in the design aspect of the unit.

Demonstrations of these different power styles will also used in this lesson. This will make the benefits and drawbacks of each type more evident and allow the students to get a better comprehension of this section.

Lesson 6:

- Boolean Algebra
- Logic
- Gate
- Truth Tables
- Uses for Logic in Robotics

In this lesson we will give the students a rough explanation on Boolean algebra and the idea of logic. Logic is very important in communication with robotics because all robots and computer systems operate in this way. The concept of Boolean algebra is a fairly simple and can be taught by using the traditional 1's and 0's, or by black and white cards (Morse code). Many of these ideas have been introduced in the communications lesson, but this section will explain it in a more detailed fashion.

The Boolean algebra and logic portions can be explained in a rather easy fashion and the idea of gates and functions of Boolean algebra will be discussed with some practice examples to follow. The idea of a truth table will also be introduced and hopefully the students will have some idea of how a system of gates would work and the output with certain inputs. Once these concepts have been somewhat understood, a game will be played where the students must devise a logic system with four inputs and certain requirements.

All of these concepts will then be used to further the student's understanding of how a robot "thinks", which will only better their ability to communicate with a robot. The lessons on communication will also help the students with their computer skills as well.

Lesson 7:

- Instructions on the project
- Hand out of the project
- Design time

At this point in time the groups will be firmly reestablished and each of the groups will be given instructions on the project they are to complete. The students will need to use the knowledge of robotics that they have just learned in the last week and design a robot that needs to complete a certain task in a certain environment. Each group will need do include all of the characteristics discussed in the previous lessons in their final design. The groups will also be aware that their designs will be looked at and critiqued by another group. This is done in hopes that the groups will perform in a competitive atmosphere.

The project will then begin and each group will have 2 lessons to finish the design of their project, so they will have to make sure mange their time and develop the most important parts of the robot first.

Lesson 8:

- Design time
- Collect the project

Again, each group only has 2 lessons to complete their project design and at the end of this lesson period the projects will be collected.

Lesson 9:

- Swap the project with a different group
- Perform critique analysis

At the start of this lesson period each group will receive another group's project design, as well as that group's problem statement-the problem that they needed to solve. Each group will now access the other group's design and give a presentation to the class as to how the design met or did not meet the specifications, and any suggestions that they might have for the group to meet the requirement needed.

Lesson 10:

- Question and Answer
- Instructors evaluations of the projects
- Post-Questionnaire
- Future of Robotics

This last lesson is reserved for any questions that the students may have about the project, robotics, or the curriculum itself. Also, at this time we will be asking the students to complete a post-questionnaire. Each of these will help us in evaluating the success of our curriculum unit. Once those are complete we will engage the students in a final discussion on the future of robotics. This discussion would include ideas of where robotics is going and what improvements could be made to existing robots.

3.4 Teaching Tools

Lesson 1:

- ***Pre-Questionnaire*:** See Appendix C for the copy of the questionnaire

Lesson 2:

- *Handouts*: These will be quick reference sheets kept by the students to help them in understanding robotic history.

Lesson 3:

- *Work Envelope Game*: This will explain to the student what work envelope is and how it affects the motions of the robot.
- *Diagrams of Types of Robots*: These diagrams will show different styles of robots

Lesson 4:

- *The Blind Game*: The student will be blindfolded and instructed by his teammates to pick up the block.
- *XYZ*: A three-dimension axis system will help students understand the coordinate system.
- *The Blind XYZ Game*: The student will be blindfolded and instructed by his teammates to pick up the block using the XYZ coordinate system.

Lesson 5:

- *Electrical components and Motors*: Giving the students a "hands-on" look at what electrical systems are made of and what they look like will help them better understand electrically powered robots.
- *Syringes*: The syringes can be used to explain both the pneumatic and hydraulic powered robots, because one deals with air and the other, liquid.

Lesson 6:

- ***Black and White flash cards*:** The cards can be used to represent high and low, or just the fact that Boolean algebra only contains two units.
- ***Nuclear War Problem*:** This problem gives the students practice in logic systems involving gates.

<u>Lesson 7:</u>

- ***Peer Evaluated Projects*:** This aspect will hopefully encourage some friendly competition between the groups, in hopes of increased desire to do well on their own projects.

<u>Lesson 8:</u>

- ***Two Lesson Limited Projects*:** By only allowing the students to have two lessons in which to complete their project design, it forces each groups to manage their time properly and lessen any nonsense.

<u>Lesson 9:</u>

- ***Presentation of Evaluations*:** If each group is made to present their critique of the another groups project then they may more constructive than detrimental, because their own project are being evaluated as well.

<u>Lesson 10:</u>

- ***Post-Questionnaire*:** See Appendix C for the copy of the questionnaire
- ***Instructor Evaluations*:** This gives us feedback as to how the instructor of the class liked our curriculum unit.
- ***Question and Answer Period*:** This allows us to evaluate the robotic designs and to answer and question about the curriculum unit.

4 Results

We made sure to follow the guidelines that the city of Worcester devised in response to the state guidelines in the hope that we would get the opportunity to personally teach the lesson plans of our unit at Doherty High School. We were lucky that a teacher at Doherty allowed us to do so, without even consulting the curriculum coordinator for the city. He was more oriented toward what his colleagues in TEAM wanted to achieve and had already decided to do something in the robotics area, so he considered us assistants rather than outsiders wanting curriculum time. The class is an elective class that involves technology and manufacturing. Tom Candito taught the 1999-2000 class, and there were fourteen students in it, 2 female and 12 male. Prior to our involvement in the class, we had Mr. Candito administer the Gordon's Cognitive Style Indicator (GCSI) to the class.

4.1 Cognitive groups

The results of the cognitive profile of the class were as follows: there were 6 Integrators, 4 Problem Solvers, 2 Problem Finders, and 2 Implementers in the class. This is surprising given that that means 10 of the 14 are remote associators, more than 66%. In the student body as a whole, we estimate that only 33% are remote associators. (John Pieper, 1996) Once this data was collected we formed four groups out of the students. We also used the help of the teacher in making these groups, because he personally knows the students and he could predict some possible "personality conflicts" between the students. The groups were created before asking for the teacher's help, and were fairly diverse in their nature. These groups were then altered with the teacher's advice to be "personality friendly" and still reasonably heterogeneous mixes. The cognitive style's grouping is listed below.

Group 1	Group 2	Group 3	Group 4
Integrator	Integrator	Integrator	Integrator
Problem Finder	Integrator	Implementer	Integrator
Problem Solver	Problem Finder	Implementer	Problem Solver
	Problem Solver		Problem Solver

Note that we were not trying to make them all the same mix, nor was homogeneity of type our goal, though at one point we had considered that possibility. Instead we took something a teacher might come up with, with random assignments given student interactions and preferences. We would then predict and observe how the different cognitive groups worked. The students were formed into these groups periodically throughout the lessons and for the most part the groups worked really well. As with any group there will be students that put more effort into the assignment than other group members, but in one particular case there was a split in the group. In Group 1, the Integrator was visibly upset with the effort of his other two group members and handed in a separate answer for the assignment for lesson 9. Despite this minor situation the group members worked very well with each other and completed the projects and the appropriate assignments that followed, despite the high level of diversity that was involved in this particular group. There was potential for conflict in this group and we knew it, but there was also potential for complementarily actions. The latter was the more typical outcome, fortunately.

4.2 Pre-Questionnaire

After the students were told about their cognitive (learning) styles a pre-questionnaire was given to the class. The questionnaire asked the students questions about their attitudes toward math and science and toward the class as well. After analyzing the questionnaire, we decided that most of the answers were very encouraging to us. This is a popular class. Many of the students enjoy the class and feel that they learn new things in the class. Most of the students are even interested in going into a future occupation in the area of science or technology and consider it relevant to their plans. Two students, even aspire to go to Mass Academy at WPI. They are not all vocational class students, so the range of ability and motivation is great. Most of the questions were answered to how we hoped they were answered, but the answers we were most interested in were to questions 32,33,34, & 35.

These questions dealt with the social aspect of science, and we were interested to see how the students related science and society, their perceptions of and optimism about technology. Question 32 asked if they agreed that "people get hurt if technology gets out of control", most of the students disagreed with that statement. Similarly, most of the students agreed with the statement that "advances in technology improve society". Most of the students also agreed that, "the benefits and advantages of science and technology outweigh the negative aspects". However, one answer that we felt did not follow the previous three was the students' answer to question 34. Most of the students disagreed that "science can solve any problem if it is given enough time and money". This answer interested us because the other three questions were answered in a pro-technology fashion. but this one expressed a sense of the limitations of science and technology.

Another answer that interested us was from question 29, most of the students felt positively about this class and they answered that way on the questionnaire. However. when question 29 asked if they agreed that "their teacher could tell what is true and what is not", most disagreed. This again seems to say that the students may have some doubts about the authority of the experts grounded in science and technology provided as their guides. So, that was the general attitude of the students taking their optional (or elective) class. The same item can be used to rank the students most to least optimistic if that seems promising later in the analysis when we turn to relative performance.

4.3 Assignments

At the end of lesson 2, the homework assignment was passed out and the students were told that they could use their handouts in order to answer the questions. The average grade for homework 2 was a 95. Every student received a 100 (perfect score), except for one. This student passed in the assignment late, and only got one of the four questions correct, so the student received a grade of 25.

The grades for homework 3 were similar to the results of homework 2, in that the average grade was 91 and the majority of the class received a 100. The student that had a 25 on the last assignment, did a little better on this one, with a 55, but it was still out of step and by far the lowest score in the class.

There was no assignment for the fourth class, however, there was an in class activity. These activity sheets can be seen below. In the first sheet (figure 2) one can see how the lines are more diagonal; this is because the students were not using the XYZ plane to command their partner. When this sheet is compared to the second one (figure 3), the difference is evident. The lines on the second sheet are rectangular and only move in one direction at a time.

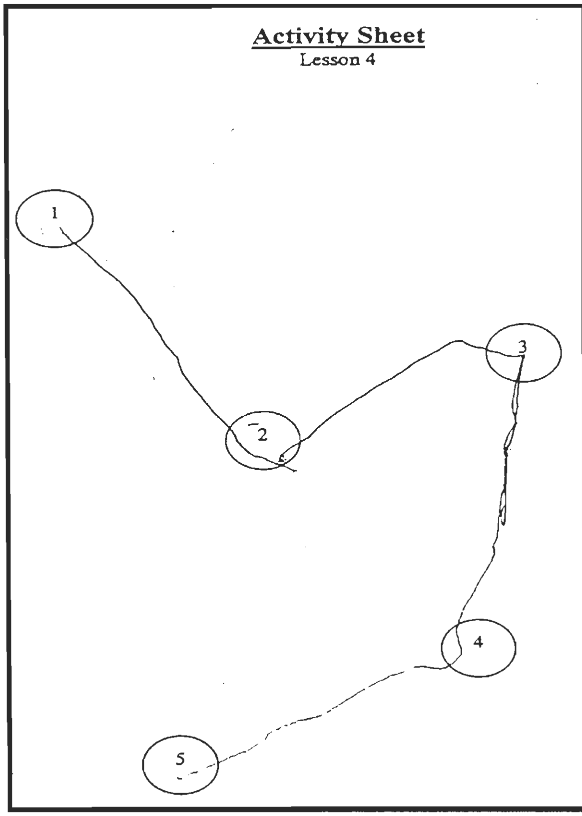

Figure 2:Without XYZ

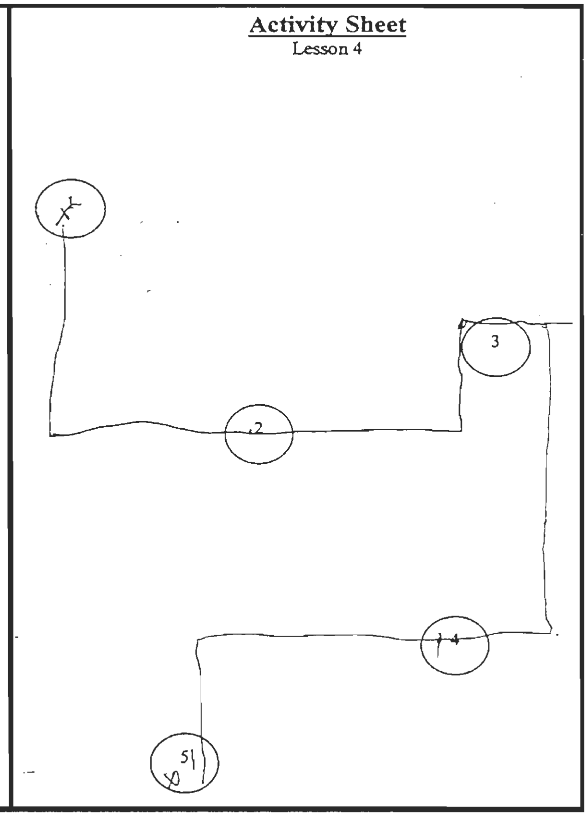

Figure 3: With XYZ

The next assignment was homework 5 and the results were very encouraging. All of the students but two received a grade of 100, and the average grade was a 93. One student got only one question wrong, but the student who previously scored lowest on the last two homework assignments was still out of it and got a 16. From observing this student in class, we do not believe that his low grades stem from a lack of intelligence. We believe that it is a result of a lack of effort and an apathetic attitude.

The next lesson was lesson 6, and it was probably the hardest lesson for the students in the whole curriculum. This lesson involved Boolean algebra and logic gates. We knew beforehand that this lesson might have been a little too difficult for a 10th grade high school class. However, we felt that the concept was very important and it needed to be introduced. At the end of the class it was decided to go over the homework assignment as a class assignment, and all received a 100 for their efforts, as they achieved mastery in the end.

The next couple of lessons were dedicated to the design project and group work. All four groups did very well on their design projects and all showed an understanding of the material taught in the previous two weeks. The grades ranged from 90 to 98, all within an "A" range. Two of the groups always worked well together, and the others usually did. The only major exception was mentioned previously in the group one having a member with higher standards than his partners, who once finally did part company with them to protect his grades.

The next group assignment was for the groups to discuss if the robot that they just designed was the best solution for the task or if it would be better suited for a human. The groups were told to think about the jobs that would be lost, and well as the safety of the human workers. All four groups were in favor of the robot that they had created. They were concerned about the jobs that would be lost, but most of the groups felt that using robotic technology creates a smarter, more productive society. They were indeed technology optimists and not concerned about reducing the skill required by the average worker or displacing them entirely.

The last assignment for the group work was the design project critiques. Each group was given another group's design project and asked if they would make any changes and what would they change it to. This assignment allowed the students to see that there is not only one solution to a problem. Also the students were told that there are no right and wrong answers if the robot still can do the job; there can be better or worse with reference to a criterion, but often it is just a difference of style, or taste, or efficiency, or simplicity. All of the groups described feasible changes to the other group's project that they would make to complete the required task "better". These critiques were evaluated and bonus points were added to their projects, based on their changes.

4.4 Post-Questionnaire and Teacher Evaluation

The final class of our curriculum consisted only of administering a post-questionnaire to the students and an evaluation of the lessons from the teacher, Mr. Candito. The results from the post-questionnaire were very good. On average the class responded with 4 out of 5 ("quite a bit") on questions 3,4, and 5. Those questions asked if they enjoyed the class, if put a lot of effort into the class, and if what they had learned was very important. The majority of the students also favored spending more time studying robotics and that they had an interest in robotics, or had developed one in class.

Another question that we felt important was if the students felt that if science and social studies were related. A majority of the class felt that they were. This answer is encouraging because this means that the students can see the correlation between science and social studies, and they would be open to a STS curriculum.

All of the class feels that science is interesting and important, while most feel that math is important, but not all think that it is interesting. We figured the lack of interest in math is all right as long as they see the importance of it, which they do. The differences and perceptions raise questions about motivation and attention to task, however.

Questions 17 and 19 were important to us because they were direct questions on the lesson plans that we had designed. On average, the students felt that this robotics lesson was slightly better than their previous science lessons in this course. Also, all but one student said that they would rather have other science units delivered the same way this robotic unit was taught, than in the usual way.

To analyze the performance of the class we combined the important results from the post and pre-questionnaire into table 1. On this table, 1 equates to a low ranking, while 5 is the highest ranking.

				How much did you enjoy this class?		How much effort did you put into this class?		How interesting did you find the unit?	
Group	Cognitive Style Mix	Previous Grade	Unit Grade/Project Grade	Pre Test	Post Test	Pre Test	Post Test	Pre Test	Post Test
1	Integrator	A	A/95	2	/	2	/	4	/
1	Prob. Finder	B	A/95	4	/	4	/	5	/
1	Prob. Solver	B	A/95	3	3	3	3	4	4
2	Integrator	C	A/98	3	/	3	/	3	/
2	Integrator	A	A/98	3	3	3	4	5	4
2	Prob. Finder	B	A/98	4	/	4	/	5	/
2	Prob. Solver	B	A/98	1	4	1	5	5	5
3	Integrator	C	D/92	2	3	2	3	3	4
3	Implementer	B	A/92	4	5	4	4	3	4
3	Implementer	A	A/92	4	4	4	5	5	4
4	Integrator	C	A/90	3	4	3	4	5	4
4	Integrator	A	A/90	2	3	2	3	5	4
4	Prob. Solver	B	A/90	3	/	3	/	2	/
4	Prob. Solver	C	A/90	2	/	2	/	3	/

Table 1: Questionnaire Results

The first analysis that can be done from the table is comparing previous average grades to the one that they received from us at the conclusion of our unit. Everyone received an A from us except for one student, who got a D. These grades could be expected for most of the students, because most of the students put in more effort throughout our unit than they did previously in the class. Three of the students far exceeded their previous expectations to receive A's in this class. The students who received the D, was definitely below his average. However, the previous grades data were self-reported, taken from the questionnaire given out with the cognitive styles test, and the students could have put down any grade that they so choose. From this data alone, it could be argued that our project was a success, but there are a couple of more points to analyze.

One of the major facets of our project is the group dynamics. The groups can be seen in table 1, along with the cognitive style of each student in the group. From first examining the make-up of the groups, it can be predicted that groups 1 and 2 would be the most productive, followed by groups 3 and 4. Groups 1 and 2 have very similar structures, with group 2 having a second Integrator, and one could guess that the integrator in each group could easily relate to the other members of the group. Problem Finders and Problem Solvers are dissimilar in both the differentiation and remote association categories, however an Integrator has similarities between both of them and can use that to make the group work.

This idea held true for group 2, this group worked very well together, with everyone participating. They also received the highest project grade in the class. This group excelled due to their grouping and was able to exceed their expectations. Now, while group 2 did very well, group 1 did have some group problems. Rather than the Integrator being the link for the group to work, he broke from the group and at one point submitted a separate paper. He did not attempt to work the other two students in the group and they were forced to work together. Despite this rift in the group, they designed a more than capable robot for their project and received the second highest grade.

Group 4 was predicted to be the next productive group because the group contained students that all scored high on the remote association section. However, when this group is looked upon closer, one can see that there one "stronger" student with three "weaker" students; this is taken from the previous grades section. This "stronger" student (Integrator) became the leader of the group and at some points throughout the project was doing noticeably more of the work, while the other three did not participate. This situation was evident in their final project and received the lowest project grade in the class. The "stronger" Integrator did not get any feedback from her group members and wrote what she felt was the best solution.

At first look group 3 seemed as if it was destined for failure. It is comprised of an Integrator and 2 Implementers; two groups that are polar opposites stylistically. One could also predict that in this group the Integrator would be the leader of the group and delegate roles to the other two group members. However, this is not how the group worked out. As one can see from table 1 the Integrator in this group is the student that received a D in our unit. He did not put forth any effort into this unit and one of the other group members needed to step up. One of the Implementers took leadership of the group and made sure that the other two participated in the project. This group definitely exceeded expectations did a good job on their project. However, it was less innovative, more solid but a success, seemingly against all odds.

One of the last analyses that can be performed on the data from table 1 is the comparison of post-questionnaire answers to the pre-questionnaire answers. The first question that we compared was the enjoyment of the class. On this item of the pre-questionnaire there were many low answers and no 5's recorded, while the post-questionnaire revealed that our unit was more enjoyable than what the class was previously.

The second question selected dealt with the amount of effort that each student put forth in the class. From the pre-questionnaire, it was obvious that the students did not put much effort into the class. This lack of effort could either be due some students feeling that the class was easy or just plain apathy. In each instance, the answers on the post-questionnaire were higher or the same. His increase in effort could follow along with the enjoyment of the class or that maybe our unit was a little more challenging than what was being previously done in the class.

The last question that we selected for analysis involved the interest of the class. From the pre-questionnaire answers, one can see that there is definite interest in this class. This class is an elective so this is not surprising because the students choose to be there. While a couple of answers on the post-questionnaire were one level lower than on the pre-questionnaire, the average answer on the post-questionnaire was about a 4, which is a still a high mark.

Over all the response from the students about the robotics curriculum was positive and teacher's evaluation expressed similar approval. Mr. Candito enjoyed the historical and social context, because "it gave the students and ability to relate past and present events." He also stated that he will incorporate the robotic lessons into his own robotic unit next year, and that he would be happy to do any future projects of this kind with WPI students.

4.5 Cranston Area Career and Technical Center Outlook on Telegraph

Our first curriculum that we presented to the teachers at Doherty High School involved the subject of the telegraph and not robotics. We felt that the telegraph theme had a longer and more intriguing history and the relationship with society would be easier to see in a STS curriculum. However, Doherty asked us if we could change the subject to robotics because they were already planning on doing a robotics unit, and because of our background, explained above, we were very confident in our ability to write a STS robotic curriculum.

Despite the switch in subject matter, we still felt that the telegraph idea was a good one, and hoped to try it somewhere. Due to time restraints, we were not able to write a second STS curriculum, but we did go back to the Cranston Area Career and Technical Center in Cranston Rhode Island to talk to our former teacher, Edd Spidell. We asked Spidell, if he thought that the telegraph idea was curriculum that he would be inclined to us. He saw the same potential in the telegraph lessons as we did, and we both hope that in the future another IQP team may try our telegraph idea.

5 Conclusions

One of the main conclusions that we would like to draw from this project is how well the STS curriculum that we wrote did in a classroom environment. From the performance of the students in the class and the evaluations we are confident that our project was a successful one, that works in the classroom.

5.1 Initial Idea

As was stated above our initial subject material for this project was not robotics but rather the telegraph. Doherty High asked us if we could write a curriculum on robotics because it fit their needs better. We accepted this change because of our background. Even though we still feel that the telegraph would make for a better STS curriculum, we took Maria Salvati's warning that if our unit was to be used, we had to fit the existing curriculum context. The audience that mattered, the teacher, was pleased and will use and build on our start. Our initial idea would be acceptable in another school, so a site has been found.

We believe that one of the reasons that Doherty High was not interested in our initial idea was because they are worried about the upcoming MCAS test. Even though our project would be following along with the goals of the state and city guidelines they were not willing to change any part of their plan for the technology curriculum. Many other IQP projects, similar to ours have been trying to get approval to teach their lessons in a Worcester Public School, but the interest from the schools was not there. Especially from the schools that did poorly on the practice MCAS, they did not allow any experimentation with the curriculum. One other project on Nuclear Power will be done in the Nashoba District, which did well on the MCAS. Another will be done on a health unit and thus the science in it will be out from under the science and technology curriculum guidelines.

We alone got into the Technology/Science curriculum in Worcester this year. We believe that the fact that we could alter out project to fit their needs helped us greatly. Also, we did not go through the central administration of Doherty High to get permission. The other projects were hanging up at CAB, and the teachers and their goals were not getting taken into consideration. The value of the science in the unit was not getting assessed in a general context but only vis a vis the likelihood that it would be good test preparation. In our case we would probably have been turned down in principle, unless a telegraph unit was already under consideration, but not already done, so that our effort would not be redundant. We would not have the opportunity to negotiate the topic with the proposed end user, if we had gone through CAB.

5.2 Doherty High School

Once we were in the classroom teaching our lesson plans all went very well. All but one of the 14 students did very well in the class, and that one student is the only one that we would consider not passing. The one errant student seemed to not do well in the class because he did not care to be there and did not put in any effort to do well. Of the ten lessons he was only absent for 2 of the classes, yet all of his assignments were handed in late. Another student was absent 4 times yet he made up all of the missed assignment the next day and fully participated in the class discussions. Why he rebelled against us, if he is really a B student normally, is not clear.

Most the time the conduct of the class was very good. As expected there were some students that acted up from time to time, but for the most part there were no problems. When the class was split into its groups for the design project work, there was some times where the room needed to but quieted down and encourage the students to work on their project.

All in all, we conclude that our STS robotics curriculum was a successful project. The students all learned about robotics and enjoyed the way that it was taught. Most of the students participated in the class discussions and the hands-on activities really seemed to help them understand certain concepts. The teacher of the class also enjoyed the project and stated that he will use our lesson plans in the future and this is a good indicator of the success of this project.

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7 Appendices

Appendix A

Lesson Plans

Lesson 1

General Introduction

Objectives

1. Introduce idea of robotics
2. Find out more about the students
3. Introduce the cognitive groups

Lesson Materials

1. Short Introduction (10 minutes)
   a. Hand out and go over the syllabus (see syllabus in appendix E)
   b. Activity-have the class come up with ideas of what they think a robot is.
2. Pre-Questionnaire (20-25 minutes)
   a. Hand out the questionnaire and have the students finish it in class (see questionnaire in appendix C)
3. Cognitive Groups (10 minutes)
   a. Break up the students into the following cognitive groups:
   b. Explain that the reason we are breaking them into these groups is for them to experience how to work in a teamwork environment with students having many different personalities and learning styles.

Lesson 2

History and Social Context

Objective

Teach the students the history of robotics and the social implications of robots throughout history.

Lesson Materials

1. Early history of robotics.
   a. Idea of robots is not new; automatons have been in use for thousands of years.
   b. Egyptians used lever action dogs in their tombs.
   c. In the Middle Ages, clockworks were used to make figurines move and ring a bell.
   d. On top of a 14th century cathedral in Strasbourg, France there is a mechanical rooster that crows and flaps it wings on the hour.
2. Origin of the word robot.
   a. The word robot is derived from the word "robota", which means forced labor in Czechoslovakian.
3. Early depiction of robots in literature.
   a. The word robot was first used in 1921 in a play written by Karel Capek, called *R.U.R.* (Rossum's Universal Robot).
      i. This plot of this play revolved around a man who built a robot (android) and then the robot wanted freedom and killed its creator.

b. Many other books and plays were written that made robots harmful and detrimental to humanity.

4. Early depiction of robots in movies.

   a. Robots first appeared in movies in 1926, in Fritz Lang's *Metropolis.* Again, robots were created with harmful tendencies towards humans.

   b. Other movies were also made during this time with the same theme.

5. Early social attitude towards robots

   a. Due to the depiction of robots in the books, plays and movies of the 1920's, the social attitude towards robots was not good.

   b. Society during this time was not contemplating the helpful uses of robots in industry or in the home.

      i. During the early 1920's American society was carefree and did not concern themselves with thoughts of science and technology.

      ii. Then in the late 1920's through the 1930's America was in the Great Depression and did not have the money or effort for science.

6. Isaac Asimov

   a. Changed the attitude of many towards robots

   b. Coined the word "robotics" and predicted a robotic revolution, where the potential of robotics would be realized.

   c. In 1950 wrote *I,Robot* and developed the three laws of robotics.

      i. First Law - A robot may not injure a human being, or, through inaction, allow a human being to come to harm.

        ii. Second Law - A robot must obey the orders given it by human beings, except where such orders would conflict with the First Law
        iii. Third Law - A robot must protect its own existence, except where such protection would conflict with the First or Second Law
    d. Portrays robots in a more helpful and productive environment.

7. Introduction of robotic companies
    a. In 1956 George Devol and Joseph Engelberger developed the first robot company.
    b. In 1961 the first industrial robots were used at General Motors in New Jersey.
    c. Many more robot companies begin to develop and industrial robots are in more places than just in automobile factories.

8. Change in social attitudes towards robotics.
    a. Due to the writings of Asimov and society being able to see the practical applications of robotics, many of the attitudes are now more positive.
    b. Society during the 1950's and 1960's are more technology ready.
        i. The idea of space exploration has captured the attention of the American people
        ii. The economy is better than twenty years ago, which adds to the evolvement of science and technology

9. Recent depiction of robots in movies and television
    a. More recent movies and television have portrayed robots as human helpers
        i. Star Wars - R2D2 and C3PO were helpful to Luke Skywalker

   ii. Short Circuit - Number 5 was actually hunted, rather than hunting and trying to kill humans
   iii. Star Trek - Lieutenant Data was an android that was very helpful and knowledgeable.
 b. Not all movies or television shows that deal with robots portrayed them positively, however many more Americans can realize the applications of robots.

10. Future of Robotics
 a. Practical applications of androids and Artificial Intelligence (AI) are far off, but that aspect of the robot has remained unchanged for years.
 b. Activity - ask the students to make predictions on the future of robotics.

Homework Assignment

History Questionnaire (see Appendix F)

Lesson 3

Robot Overview

Objectives

Familiarize the students with the different types of robots, vocabulary words, and where and when to use robots.

Lesson Materials

(C. Bastone, 1989)

Six Robot Characteristics Already, there are many types of robots in use both inside and outside the factory. These can be classified according to six different characteristics: use, mobility, motion control, capability, arm configuration and end effector. We will look at each of these classifications.

1. **Use Of Robot** Robots can be classified according to the type of use. The two main categories of use are industrial and non-industrial robots.

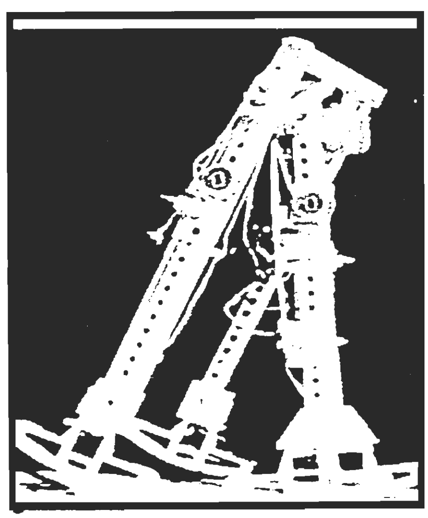
   a) **Industrial Robots**
   Industrial robots were first used on the factory floor in welding, painting, and materials handling. Most factory robots are primarily fixed location manipulative "arms and hands". Industrial robots are now starting to be outside of the factory in construction, mining, forestry, and agriculture.

   b) **Non-Industrial Robots**
   Non-industrial robots include a wide range of robots which serve in areas other than the industrial workplace. They include:
   –Dangerous Environment Robots: bomb disposal, underwater radiation hazard, chemical spills, and fire fighting
   –Social Welfare Robots: assisting nurses and the disabled
   –Domestic/Personal Robots: future tasks include cleaning and security
   –Educational Robots: to teach and familiarize students and hobbyists with the major concepts of robotics
   –Show and Entertainment Robots: used for advertising in malls, conventions and fairs and also in television and films

2. **Mobility** The ability to change locations classifies robots as fixed or mobile.

   a) **Fixed Robots**
   Fixed robots can only work within a limited space or area. Until recently all industrial robots were fixed to a pedestal base which was bolted to the floor but now some fixed robots are mounted to provide limited mobility. They can be supported from an overhead gantry to save floor space or secured on a short track or rails.

   b) **Mobile Robots**
   Mobile robots permit work in a variety of locations. Three main types of land locomotion are used: wheeled, tracked and



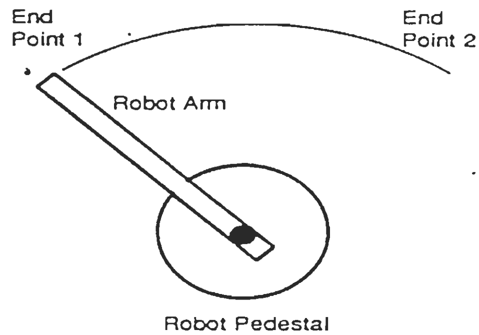
Above: Yama Robot

YAMA is an interesting research robot which has two leg frames. Most other mobile robots try to mimic the joint movements of human legs but YAMA swings its legs like a pendulum! (Printed with permission, Center for Systems Science, Simon Fraser University, Vancouver, B.C.)

legged. Normally, legged robots have four to six legs; two-legged robots are presently very difficult to make. Other types of locomotion include propeller drive systems for submersibles.

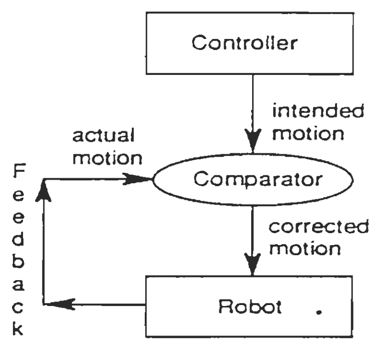
3. **Motion Control** The type of motion control determines the level of complexity of robot movement. There are two main types of motion control systems used in robots: non-servo controlled and servo-controlled.

   a) **Non-Servo Control**
   This is the simplest form of robot control. Non-servo robots have their movements set and limited by mechanical end stops. Movement continues until it literally "bangs" in to the end point. It is not possible for the robot to accurately stop between these two points. These robots are only useful for simple tasks where movement between two points in space is all that is required. They are sometimes called "pick and place" or "bang-bang" robots.



A Non-Servo "Bang-Bang" Robot

   b) **Servo-Controlled Robots**
   Servo-controlled robots are much more flexible than non-servo robots. A servo-controlled robot can be made to stop at any number of points within its working space. This extra control is made possible by the use of a feedback system. There is a built-in sensing ability that constantly "feeds back" the actual position and compares it to the intended position. Constant corrections are made automatically to reduce the tracking error. Precise movements accurate to less than 2mm (1/16 in.) are made possible! Servo-controlled robots permit the complex tracking of perfect straight lines, curves and circles.



The Servo Feedback System

4. **Capability** Capability refers to the level of "intelligence" of the robot. There are three generations of robots:

   a) **First Generation Robots**
   First generation robots include both playback and numerically-controlled (NC) robots. Playback robots memorize a route which it has been "taught" by a human operator who physically guides the robot along the desired route. An excellent example of a playback robot is a spray painting robot which has memorized the movements of a human spray painting an object. The robot repeats exactly what is was taught.

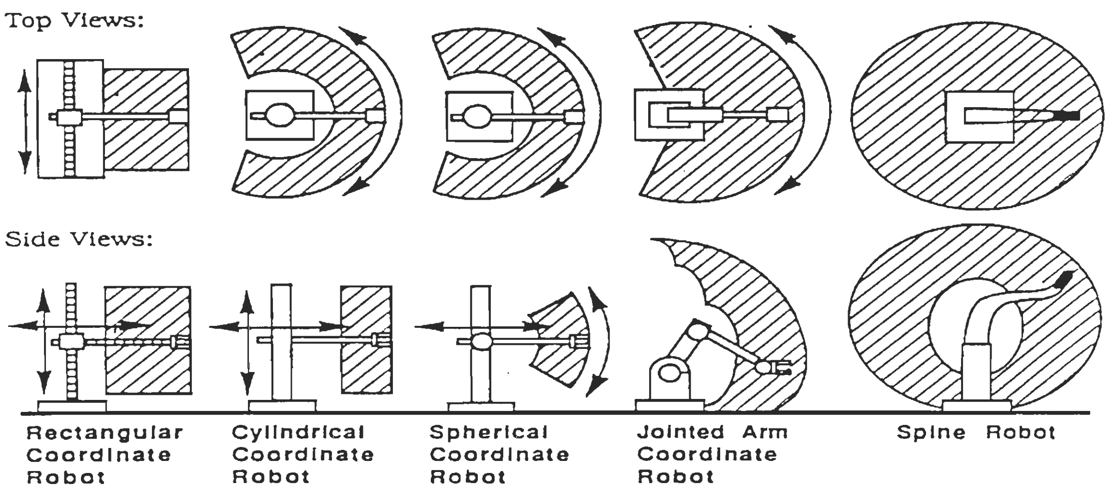
   Numerically controlled (NC) machines are more advanced in that no physical teaching is necessary. The movements are programmed directly into the computer memory by the robot programmer.

   The main disadvantage of first generation robots is that they have little or no sensory feedback. If a piece of material to be drilled was incorrectly positioned it would drill it anyway. Or, if a human wandered in front of the robot while it was welding, it would be happy to weld him to the job!

b) **Second Generation Robots**
Second generation robots incorporate basic sensory systems to feedback information to the computer controller so that they can respond to their environment. For example, infrared sensors might detect that a human has entered the danger zone. This information is fed back to the computer, a decision is made based on memorized "choices", and the robot is stopped. Second generation robots are sometimes called adaptive robots.

c) **Third Generation Robots**
Third generation robots will be those robots that use artificial intelligence (AI) computers. These intelligent robots will be able to recognize, learn and think. They will be able to program themselves and adapt to new situations not previously known to them.

5. **Arm Configuration** Robots that have arms can be classified according to their arm type configuration or arrangement and the shape of motion or work envelope (the three dimensional volume of space in which the robot manipulator is capable of working). Each of the five basic work envelopes will be illustrated using a top view and a side view. The combined views make the three dimensional work envelope shape.



a) **Rectangular Coordinate Robot**
This robot has a cube shaped work envelope. The side view shows that its horizontal arm can rise and fall on the vertical column and also move in and out. The top view shows that it slides back and forth on its base instead of pivoting. These robots are easily programmed, relatively inexpensive, and very precise in operation.

b) **Cylindrical Coordinate Robot**
This work envelope is a portion of a cylinder. In the side view it can be seen that the arm has the same movements as the rectangular coordinate robot. However, in the top view it can be seen that the entire arm can pivot or rotate around the base, although it cannot rotate a full 360 degrees.

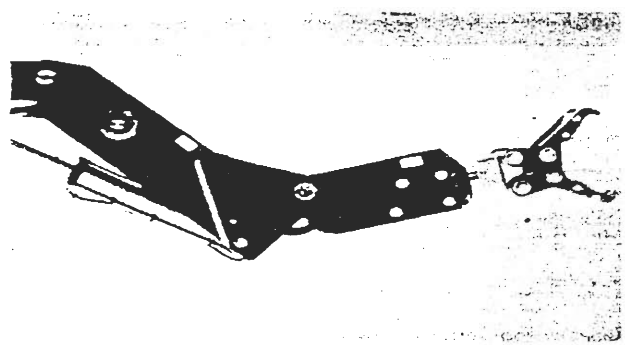
c) **Spherical Coordinate Robot**
The work envelope shape for this robot is a portion of a sphere. In the top view the action is the same as the cylindrical robot. However, in the side view it can be seen that it does not rise and fall on the vertical column but instead pivots up and down to form an arc. These robots are useful for lifting and moving objects.

d) **Jointed Arm Robot**
The work envelope shape is complex because of the action of the joints. This robot resembles the human arm. Its joints are called the waist, shoulder, elbow and wrist. The side view clearly shows that the robot arm can reach very low and high and behind itself. Because of its increased flexibility and strength, this robot is used often in industry; however, they are the most expensive to produce and require a complex control system.

e) **Spine Robot**
This "snake like" robot has extraordinary flexibility and has the most complete work envelope of all robots. Spine robots are best suited for work in hard to reach places such as spray painting the inside of a car. However, they do not have the same lifting ability of other robots.

6. **End Effectors** End effectors are the type of tool attached to the end of the robot arm. The ability of most end effectors to be automatically changed to a different tool is a major factor which makes robots flexible machines. The tools could be screwdrivers, wrenches, arc welders, drills, cutters, deburrers or ladles for moving molten metal. Also, special end effectors are available such as finger, vacuum and magnetic grippers.

The Kodiak 1000 6 DOF 7 Function Manipulator has a versatile gripper which can be used in hostile environments and can squeeze with a force of 250 pounds. The gripper can be easily exchanged for any compatible hydraulic tool package. (Printed with permission, Robotics Systems International, Sidney, B.C.)



Homework Assignment

Have the students think of 2 applications where a robot can be used and then identify specifications that the robot should have. Also, give two examples of first generation robots and description of each.

Lesson 4

Communications and the XYZ Co-ordinate System

Objective

This lesson was devised to give the students a background on communications and to teach them the XYZ Co-ordinate System.

Lesson Materials

1. Communications
    a. Telegraph
        i. One of the first forms of long distance communication.
        ii. The first telegraphs used a two bit system with black and white cards
        iii. Soon progressed to a larger bit system
    b. Robotic communication
        i. Computer interface
        ii. Robots are deliberate and specific
2. Activity
    a. One student is blindfolded and another student will be the communicator. The blindfolded student will act as a robot and follow directions specifically and deliberately, while the communicator will attempt to command the blindfolded student to complete a task.
3. XYZ Co-ordinate System
    a. Without the knowledge of the XYZ system the students should find that the precious activity was somewhat difficult

b. Robots operate in three dimensions; The XYZ system is a three dimensional system

    i. There are three axes that intersect at a 90 degree angle to the other two axes

    ii. The axes are represented by the letters X, Y, and Z

4. Activity

    a. This activity is similar to the previous one, except now the students are encouraged to use the XYZ Co-ordinate system.

        i. This activity should prove a little easier this time

Homework Assignment

Students will be given a set of axis and they must plot points on the axis. Then the students will be given some points and they must figure out there co-ordinates.

Lesson 5

Robotic Power Sources

Objective

To give the students a firm understanding of the three different power sources: electrical, pneumatic, and hydraulic.

Lesson Materials

1. Explanation of what each sources mean
    a. Electric - uses motors and gears in order to move the joints of the robot
    b. Pneumatic - uses air to move the joints of the robot
    c. Hydraulic - uses liquid (usually an oil) to move the joints of the robot
2. Electric Power
    a. Why electric?
        i. Allows for precise movement and control
        ii. Strong joints
        iii. Most common power source; due to their cleanliness/practicality
    b. Voltage
        i. Explanation of voltage
        ii. Idea of high and low voltage
        iii. Voltage symbols
    c. Current
        i. Explanation of current and electrical charge (Ohm's Law)
3. Pneumatic Power
    a. Why pneumatic?

i. Easy to implement

ii. Fast motion; non-servo

iii. Good to use when precision or accuracy are not important factors

iv. Joints are weak, because air is easily compressed

b. Demonstrate air power using syringes and straws

4. Hydraulic Power

a. Why hydraulic?

i. Very strong joints

ii. Slow, deliberate movements; precise and accurate

iii. The joints are messy, so not good for clean environments

b. Demonstrate hydraulic power using syringes and straws

i. Compare results from previous demonstration and emphasize that air is more easily compressed than liquid

Homework Assignment

For each power source give two applications and explain each supply's characteristics.

Lesson 6

Boolean Algebra and Logic

Objectives

1. To introduce students to logic and Boolean algebra
2. To show the students what it takes to implement logical functions of the robot

Lesson Materials

1. Boolean Algebra
   a. Algebra that is used to implement the binary numbers
   b. Logic signs
      i. AND (upside down U or a multiply sign)
      ii. OR (regular U or '+' sign with a circle around it)
      iii. NOT (A bar over the function)
   c. Logic manipulations
      i. AND

A AND B=C

A	B	C
0	0	0
0	1	0
1	0	0
1	1	1

      ii. OR

A OR B=C

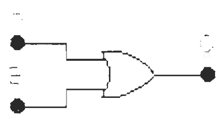
A	B	C
0	0	0
0	1	1
1	0	1
1	1	1

      iii. NOT

A NOT B

A	B
0	1
1	0

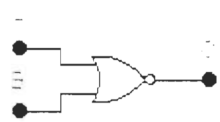
2. Logic
   a. To create Logic we must use TTL components that express Boolean algebra
   b. TTL Components, Symbols and truth tables
      i. OR
         1. Symbol of OR gate



         2. Truth Table for an OR gates

Input (A)	Input (B)	Output (C)
0	0	0
0	1	1
1	0	1
1	1	1

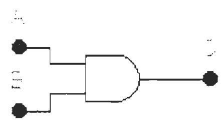
      ii. NOR
         1. Symbol of NOR gate



         2. Truth Table for an NOR gates

Input (A)	Input (B)	Output (C)
0	0	1
0	1	0
1	0	0
1	1	0

      iii. AND
         1. Symbol of AND gate

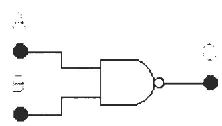


2. Truth Table for an AND gates

Input (A)	Input (B)	Output (C)
0	0	0
0	1	0
1	0	0
1	1	1

iv. NAND

1. Symbol of NAND gate

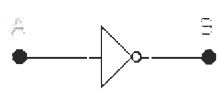


2. Truth Table for an NAND gates

Input (A)	Input (B)	Output (C)
0	0	1
0	1	1
1	0	1
1	1	0

v. NOT

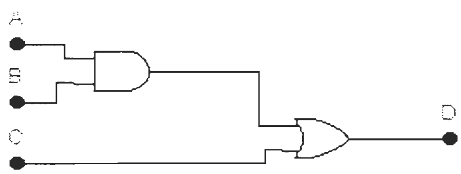
1. Symbol of NOT gate



2. Truth Table for an NOT gates

Input (A)	Output (B)
0	1
1	0

3. Example-Figure out the Truth table for the following circuit



Answer:

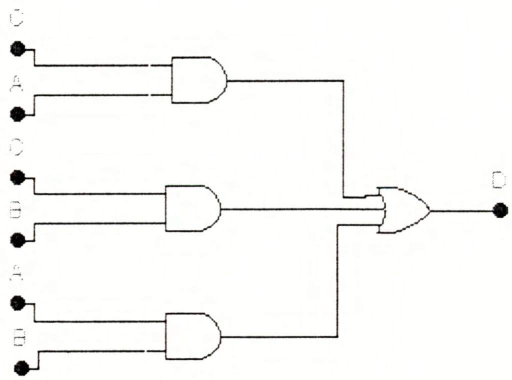
Input (A)	Input (B)	Input (C)	Output (D)
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

4. Activity-The students are head engineers in designing a nuclear launch control. In order to launch the nuclear missile two out of three main switches must be turned on. Design a logic circuit to those specifications. (Hint: Use a three input OR gate)

Three input gate Truth Table:

Input (A)	Input (B)	Input (C)	Output (D)
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

Answer:



Homework Assignment

See Appendix F

Lessons 7 & 8

Design

Objective

To have the students use the knowledge that they have obtained from the previous lessons in order to design a robot that conforms to certain scenarios.

Lesson Materials

1. Split the class into their cognitive style groups and hand out a different scenario to each group
2. Scenarios
   a. Design a robot the picks up an integrated circuit, at room temperature, and places them into its packaging
   b. Design a robot to move a car engine from one station to another in a car factory
   c. Design a robotic arm, that is attached to a submersible vehicle, that is used for exploration of shipwrecks
   d. Design a robot for a chemical plant that dip their product into baths of hydrochloric acid
   e. Design a robotic arm that tosses clay pigeons into the air for target practice
3. Requirements for each design
   a. A drawing of the robot design
   b. Type of gripper used and why?

c. Type of power supply and why?

d. The robot configuration and work envelope used

e. Is the robot fixed or mobile?

f. Is the robot servo or non-servo?

Homework Assignment

There is no assignment for Lesson 7 and at the end of Lesson 8 there will be a handout (see Appendix F).

Lesson 9

Critique

Objective

Give the students an opportunity to evaluate another group's design project and give suggestions that could improve their project.

Lesson Materials

1. Have the students exchange their project reports with another group
2. Have the students give comments
    a. Comment on what they did well
    b. Comment on what they could have done better

Homework Assignment

Write a paragraph on the future of robotics

Lesson 10

Overview

Objective

Give the students feedback and have a discussion on the future of robotics

Lesson Materials

1. Feedback
    a. Tell the students our critiques of their design projects
2. Future of robotics
    a. Discussion of the future of robotics with the students
3. Question and Answer
    a. Provide answers to the student's questions
    b. Clear up any misconceptions that the students may have
4. Post-Questionnaire
    a. Handout questionnaire and have the students complete it during class (see questionnaire in Appendix D)

Appendix B

Group Perceptions and Cognitive Style Indicator

Group Perceptions and Cognitive Style Indicator

Name ______________________

School ______________________

Home Room # ______________________

Sex - Male Female

Date of Birth - ______________________

Learning Styles Study

Worcester Polytechnic Institute

1995/1996

Student #______________

DIVERGENT THINKING

In this section you will be asked to play two different kinds of word games. Each word game will be timed by your instructor. Even if you have not completed the game you are on when your instructor calls "time", please move on to the next section. After reading the instructions for the first game, look up at your instructor so that they know you are ready to begin.

INSTRUCTIONS: You will have 3 minutes from when your instructor says "begin" to complete this word game. Below is the word Barrel. Write down as many possible uses as you can think of for this object. Let your imagination run wild if you wish since answers need not be plausible, only possible.

A BARREL

CONVERGENT THINKING

INSTRUCTIONS: In this second game you are presented with three words and are asked to find a fourth word which is related to all three. Write this word in the space to the right.

For example, what word would you think is related to these three words?

cookies sixteen heart ______________

The answer in this case is "sweet". Cookies are sweet; sweet is a part of the phrase "sweet sixteen" and a part of the word "sweetheart".

Here is another example:

poke go molasses ______________

You should have written "slow" in the space provided. "Slowpoke", "go slow", and "slow as molasses". As you can see, the fourth word may be related to the other three for various reasons.

Try these next two:

A.	surprise	line	birthday	______________
B.	base	snow	dance	______________

Answers: A) party; B) ball

The next page lists ten of these word puzzles. You will have six minutes to complete these puzzles, at which time you will be asked to move on to the following section even if you have not completed the game. When you have completed these instructions, please look up at your instructor so that they know you are ready to begin this second word game.

Word Puzzles

1.	sea	home	stomach	________________
2.	walker	main	sweeper	________________
3.	mouse	sharp	blue	________________
4.	board	magic	death	________________
5.	athletes	web	rabbit	________________
6.	note	dive	chair	________________
7.	chocolate	fortune	tin	________________
8.	blood	music	cheese	________________
9.	elephant	lapse	vivid	________________
10.	sore	shoulder	sweat	________________

Instructions: Answer the following questions:

	Word Puzzles	Barrel	Neither
Which did you prefer?	**1**	**2**	**3**
Which did you find easier?	**1**	**2**	**3**

To protect the privacy of your classmates, please dispose of this page when you have completed questions 1 and 2.

A. ____________________________

B. ____________________________

C. ____________________________

D. ____________________________

E. ____________________________

F. ____________________________

G. ____________________________

H. ____________________________

I. ____________________________

J. ____________________________

The purpose of this final section is to examine your view of the work climate and social atmosphere in which you are pursuing your studies.

After carefully reading the explanation for each question, proceed at your own speed. However, move along rapidly because first answers are usually best. That's good for us and easier for you.

Remember: When in doubt, pick you first impression, and move along.

BEFORE TURNING TO question 1 do the following:

Detach the last page of your booklet which should contain a blank list labeled A to J, and place it next to your booklet.

From A to J print in the names of 10 classmates or people with whom you have worked. In general it is best to pick those with whom you come in contact most often whether or not they are the people you like best. One need not know these people as intimate friends to answer the following general questions.

YOU WILL BE ASKED TO DISPOSE OF THE LIST OF NAMES AS YOU PLEASE AFTER USING IT ON THE FOLLOWING SECTION, SO REST ASSURED THAT THE PRIVACY OF YOUR CLASSMATES WILL BE PROTECTED. THE PARTICULAR PEOPLE YOU CHOOSE ARE OF NO INTEREST TO US.

Please turn to Question 1 and begin.

COMMITMENT TO STUDIES

Question 1 EXPLANATION

Based on your experience and observations, circle for each individual (A-J) a number from 1 - 10 which represents your opinion of how studious or serious about their work you consider that person to be.

REMEMBER The higher the number is, the more committed to serious study a person is; the lower the number is, the less committed to serious study a person is.

Please do not circle more than one number for each individual.

	Less Commitment								More Commitmen
A.	1	2	3	4	5	6	7	8	9	10
B.	1	2	3	4	5	6	7	8	9	10
C.	1	2	3	4	5	6	7	8	9	10
D.	1	2	3	4	5	6	7	8	9	10
E.	1	2	3	4	5	6	7	8	9	10
F.	1	2	3	4	5	6	7	8	9	10
G.	1	2	3	4	5	6	7	8	9	10
H.	1	2	3	4	5	6	7	8	9	10
I.	1	2	3	4	5	6	7	8	9	10
J.	1	2	3	4	5	6	7	8	9	10

CREATIVITY

Question 2 EXPLANATION

Based on your experience and observations, circle for each individual (A-J) a number from 1 - 10 which represents your opinion of that person's creative (or innovative) ability; that is, the ability to be original or bring something new into existence, such as new products, ideas, or processes.

REMEMBER The higher the number the more creative a person is; the lower the number the less creative a person is.

Please do not circle more than one number for each individual.

	Low									Hig
A.	1	2	3	4	5	6	7	8	9	10
B.	1	2	3	4	5	6	7	8	9	10
C.	1	2	3	4	5	6	7	8	9	10
D.	1	2	3	4	5	6	7	8	9	10
E.	1	2	3	4	5	6	7	8	9	10
F.	1	2	3	4	5	6	7	8	9	10
G.	1	2	3	4	5	6	7	8	9	10
H.	1	2	3	4	5	6	7	8	9	10
I.	1	2	3	4	5	6	7	8	9	10
J.	1	2	3	4	5	6	7	8	9	10

Upon completion of questions 1 and 2,

please answer the short questionaire on the next page.

DIRECTIONS: Using a lead #2 pencil, completely cover the appropriate letter:

	Correct	Correct	Incorrect
letter:	A ■ C D E	A B C D ●	X B Ⓒ D E

For all questions, a response of "G" will indicate "I don't know".

Parent's / Guardian's highest level of completed education:
A: 1-11yrs B: High School Degree C: Associates Degree(2yrs College)
D: Bachelors Degree(4yrs College) E: Masters Degree(6yrs College)
F: Doctoral Degree(includes M.D. or Law)

mother: - - - - - - -	A B C D E F G
father: - - - - - - -	A B C D E F G
guardian(if applicable) - - - - - -	A B C D E F G

Which Social Class do you identify with the most? A B C D E G
A: Lower Class B: Working Class(Blue Collar) C: Lower Middle Class
D: Upper Middle Class E: Upper Class (Doctor/Lawyer)

Parent's / Guardian's occupation:

mother ______________________________
father ______________________________
guardian ______________________________

Circle the average grade you have received in each of the following subjects over the past two years:

English - - - - - - -	A B C D F G
Math - - - - - - -	A B C D F G
Science - - - - - - -	A B C D F G
Social Studies - - - - - - -	A B C D F G

Indicate how close to your full potential you feel you have been working in each of the following subjects over the past two years.
A: full B: very close C: fairly close D: not close E: nowhere near full

English - - - - - - -	A B C D E G
Math - - - - - - -	A B C D E G
Science - - - - - - -	A B C D E G
Social Studies - - - - - - -	A B C D E G

In general, how do you rank yourself as a student? A B C D E G
A: excellent B: above average C: average D:below average E: poor

Have you taken the PSAT this school year? A: yes B: no A B

Did you participate in the Kaplan workshop, or any other preparation course, to prepare for the PSAT (or if you are a Senior, the SAT)? A B C D E
A: yes, participated in the free Kaplan workshop
B: prepared using a full length course. Which one?_______________
C: prepared using a preparation book. Which one?_______________
D: prepared using computer software. Which software?____________
E: did not prepare

Appendix C

Pre-Questionnaire
(Modderno and Tonning)

Doherty High School
Pre-Questionnaire

1) What is your name?______________________________

2) Are you
   a) Male________ b) Female________

3) What is your age?________

4) Do you live
   a) in a city b) near a city (suburbs) c) in a rural area

5) What is your father's occupation?______________________

6) What is your mother's occupation?_____________________

7) What do you expect your occupation to be when you are your parents' age?

   ____

8) Rank your liking of the following subjects on a scale of 1 to 10, 1 being the lowest, and 10 being the highest:

   a) English (writing, spelling) _____

   b) Mathematics _____

   c) Life Science (biology) _____

   d) Physical Science
      (chemistry, physics) _____

   e) General Science _____

   f) Social Studies _____

   g) Reading, Literature _____

   h) Other (please specify)
      __________________ _____

9) How much are you enjoying this class?

not at all	not much	about average	quite a bit	very much
1	2	3	4	5

10) How often do you learn about new things in this class?

not at all	not often	about average	quite often	very often
1	2	3	4	5

11) How much effort would you need to put into this class in order to get an A?

none at all	not much	about average	quite a bit	very much
1	2	3	4	5

12) How much effort are you putting into this class now?

none at all	not much	about average	quite a bit	very much
1	2	3	4	5

13) Do you expect to do well in this class?

No, not very well	below average	average	above average	yes, very well
1	2	3	4	5

14) How important will the information you learn in this class be to your life?

not at all important	very important	somewhat important	important	very important
1	2	3	4	5

15) How important will the information you learn in this class be to future schoolwork?

not at all important	very important	somewhat important	important	very important
1	2	3	4	5

16) If it were up to you would you spend more or less time studying this topic?

much less time	less time	about the same	more time	much more time
1	2	3	4	5

17) How much more would you like to learn about the subject of this class in the future?

nothing	not much	somewhat more	quite a bit	very much
1	2	3	4	5

18) Each of the following lines contains a pair of words. Select on the scale where you feel your view of science fits best:

a. facts	1	2	3	4	5	concepts
b. lively	1	2	3	4	5	boring
c. easy	1	2	3	4	5	hard
d. stable	1	2	3	4	5	changing
e. traditional	1	2	3	4	5	new
f. experiment	1	2	3	4	5	real world
g. human	1	2	3	4	5	technical
h. competitive	1	2	3	4	5	cooperative

19) How much confidence do you have in the people running the following organizations?

	a great deal of confidence	only some	hardly any	none	don't know
a. The president of the U.S.	1	2	3	4	0
b. President of Large Companies	1	2	3	4	0
c. Leading scientists	1	2	3	4	0
d. Television news teams	1	2	3	4	0
e. Leader of environmental groups	1	2	3	4	0
f. Well known teachers	1	2	3	4	0
g. Military officers	1	2	3	4	0

20) How smart would one have to be to understand the material taught in this class well enough to use it in an important job?

very smart	above average	just average	most people could do it	any one could do it
1	2	3	4	5

21) How likely is it that you would want a job that involved using the material from this course?

very likely	likely	not likely	not at all likely	don't know
1	2	3	4	5

22) How likely do you think it is that you would do well in more advanced courses in this subject?

very likely	likely	not likely	not at all likely	don't know
1	2	3	4	5

23) How likely is it that you will go to college and study to become a scientist or engineer?

very likely	likely	not likely	not at all likely	don't know
1	2	3	4	5

24) How important are the contributions of scientists to society?

very important	important	not important	not at all important	don't know
1	2	3	4	5

25) Circle the choice that best describes your view of science.

Science is:
1) interesting but not important
2) important but not interesting
3) important and interesting
4) not important and not interesting

26) Circle the choice that best describes your view of math.

Math is:
1) interesting but not important
2) important but not interesting
3) important and interesting
4) not important and not interesting

Please circle the number that most closely represents how much you agree or disagree with the statement.

27) When the scientists can't agree on what is true, and what is not, the teacher should not mention that material in a course until they are in agreement.

strongly agree	agree	disagree	strongly disagree	don't know
1	2	3	4	5

28) The teacher is very confident that what we are being taught is true, and will always be true.

strongly agree	agree	disagree	strongly disagree	don't know
1	2	3	4	5

29) I believe that my teacher can almost always tell what is true and what is not.

strongly agree	agree	disagree	strongly disagree	don't know
1	2	3	4	5

30) Science courses should include brand new material even if that means we need to learn about two or three theories that are still being disputed.

strongly agree	agree	disagree	strongly disagree	don't know
1	2	3	4	5

31a) Science helps me learn how to think more clearly.

strongly agree	agree	disagree	strongly disagree	don't know
1	2	3	4	5

31b) Math helps me learn how to think more clearly.

strongly agree	agree	disagree	strongly disagree	don't know
1	2	3	4	5

Appendix D

Post-Questionnaire
(Modderno and Tonning)

Doherty High School

Post-Questionnaire

1) What is your name? ________________________________

2) Rank your liking of the following subjects on a scale of 1 to 10; 1 being the lowest, and 10 being the highest:

a) English (writing, spelling)

b) Mathematics

c) Life Science (biology)

d) Physical Science (chemistry, physics)

e) General Science

f) Social Studies

g) Reading, Literature

h) Other (please specify)

3) How much did you enjoy this class?

not at all	not much	about average	quite a bit	very much
1	2	3	4	5

4) How often did you learn about new things in this class?

not at all	not much	about average	quite often	very often
1	2	3	4	5

5) How much effort did you put into this class?

none	not much	about average	quite a bit	very much
1	2	3	4	5

6) Do you think you did well in this class?

No, not very well	below average	average	above average	yes, very well
1	2	3	4	5

7) How important will the information you learned about science and technology in the Robotics unit be to you later in life?

not at all important	not very important	somewhat important	important	very important
1	2	3	4	5

8) How important will the information you learned about social studies in the Robotics Unit be to you later in life?

not at all important	not very important	somewhat important	important	very important
1	2	3	4	5

9) How important will the information you learned in the Robotic Unit be to your future school work?

not at all important	not very important	somewhat important	important	very important
1	2	3	4	5

10) If it were up to you, would you spend more or less time studying this topic?

much less time	less time	about the same	more time	much more time
1	2	3	4	5

11) How interesting did you find the Robotic Unit?

not at all	not much	about average	quite a bit	very much
1	2	3	4	5

12) How likely is it that you will go to college and study to become an engineer or a scientist?

not at all likely	not likely	likely	very likely	don't know
1	2	3	4	5

13) Circle the choice that best describes your view of science.

Science is:

1) interesting but not important
2) important but not interesting
3) important and interesting
4) not important and not interesting

14) Circle the choice that best describes your view of Math.

Math is:
1) interesting but not important
2) important but not interesting
3) important and interesting
4) not important and not interesting

15) Science helps me learn how to think more clearly.

strongly agree	agree	disagree	strongly disagree	don't know
1	2	3	4	5

16) Math helps me learn how to think more clearly.

strongly agree	agree	disagree	strongly disagree	don't know
1	2	3	4	5

17) How would you compare the 2 weeks spent studying the **Robotics** to other science subjects that you have studied this year.

much better	slightly better	about the same	slightly worst	much worse
1	2	3	4	5

18) Do you think Science is related to Social Studies?

strongly agree	agree	disagree	strongly disagree	don't know
1	2	3	4	5

19) If it were up to you, would you spend the whole year: (check one)

______learning different science units in the same way as the **Robotics** Unit was taught, or

______learning science the way it has always been taught.

Appendix E
Handouts

Doherty High School

Syllabus for Robotics

Contact Information

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Introduction

This part of the course will introduce you to robotics and automated systems. The unit will show how robotics evolved from movable figurines of the Middle Ages to the high tech machines that they are today. You will also have a chance to design a robot, while working in a teamwork environment and will get a chance to evaluate other team's designs.

Topics to be covered

- History of Robotics
- Types of robots
- Robot Vocabulary
- Robot Restraints
- Communications
- Power
- Logic Design
- Boolean Algebra
- Design

Grading

Here is the breaking down of the grading:

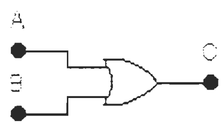
40% Homework
50% Design
10% Class Participation

Outline

1 Introduction to the Unit	**2** History of Robotics	**3** Overview of Robots	**4** Communications and XYZ axis	**5** Robot Power
6 Logic, Boolean Algebra	**7** Design	**8** Design	**9** Critique	**10** Question and Answer

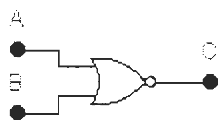
LOGIC GATES HANDOUT

OR Gate



Input (A)	Input (B)	Output (C)
0	0	0
0	1	1
1	0	1
1	1	1

NOR Gate



Input (A)	Input (B)	Output (C)
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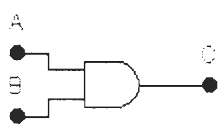
0	1	0
1	0	0
1	1	0

AND



Input (A)	Input (B)	Output (C)
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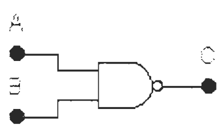
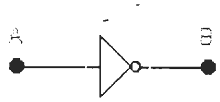
0	1	0
1	0	0
1	1	1

NAND



Input (A)	Input (B)	Output (C)
0	0	1
0	1	1
1	0	1
1	1	0

NOT



Input (A)	Output (B)
0	1
1	0

Appendix F

Homework Handouts

HOMEWORK 2

History of Robotics

NAME:____________________

1. What does the word robota in Czechoslovakian mean?

2. What was society's attitude towards robots during the 1920's?

3. How many laws of robotics did Isaac Asimov have?

4. In what type of factory was the first industrial robots used in?

5. Did you enjoy the history lesson? Do you feel History is important to learning?

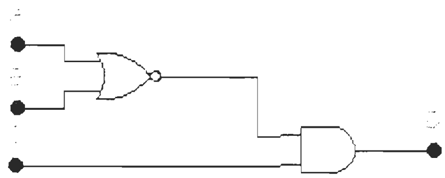
6. Do you feel you learned valuable information about the robots?

HOMEWORK 6

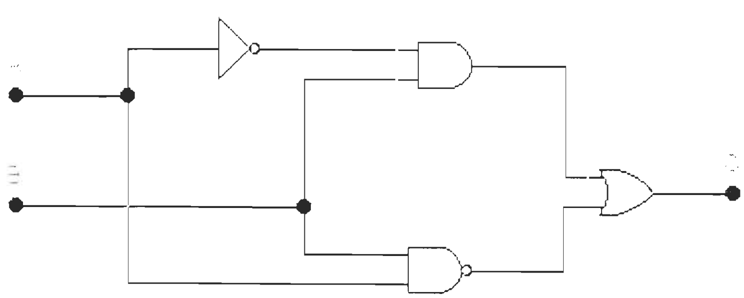
Logic

NAME: ____________________________

Complete the truth table for the following 2 circuits



Input (A)	Input (B)	Input (C)	Output (D)
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	



Input (A)	Input (B)	Output (C)
0	0	
0	1	
1	0	
1	1	

Appendix G
Cognitive Data

NAME	DIVER	STRICT	LENIENT	DID	INCORR	RAT	PREF	EASY
Peter Fallon	7.0	5	0	5	0	5	2	2
Thomas Morin	10.0	7	0	2	1	7	2	2
Nick Merolla	5.5	7	0	2	1	7	1	2
Ashley Pulin	2.0	7	0	0	3	7	3	1
Mike Mastroria	7.0	7	1	0	2	8	1	1
Mike Manning	2.0	9	0	0	1	9	1	2
Brian Foley	5.0	6	0	0	4	6	2	2
Oscar Almendare	3.0	2	0	8	0	2	1	2
Mike Belset	1.0	8	0	0	2	8	1	2
Nicholas Mahtes	4.0	8	0	1	1	8	1	1
Anthony Gentile	5.0	3	0	4	3	3	2	2
Dan Forkio	2.0	6	0	0	4	6		
Rory Campbell	2.0	7	1	0	2	8		
James Cazzaina	4.0	6	0	0	4	6	1	1
Alex Folera	2.0	7	0	0	3	7	2	2
Nichole Willbur	2.0	9	0	0	1	9	1	2
Dan Lehto	2.0	7	0	0	3	7	3	3
Scott Barrows	2.0	9	0	0	1	9	2	2
Kevin Johnson	7.0	5	0	5	0	5	2	2
Omar Vasquez	4.0	5	0	4	1	5	1	2
Jason Schlegel	4.0	5	0	5	0	5	2	2

Name	F2	F6	F7	DIFFDI	RATDICT	COGSTY
Peter Fallon	1.64	1.80	0.529	2.00	1.00	2.00
Thomas Morin	1.14	1.29	0.316	1.00	2.00	3.00
Nick Merolla	1.51	1.38	0.333	2.00	2.00	1.00
Ashley Pulin	1.44	1.51	0.267	2.00	2.00	1.00
Mike Mastroria	1.88	2.17	0.688	2.00	2.00	1.00
Mike Manning	1.13	1.39	0.250	1.00	2.00	3.00
Brian Foley	1.19	1.10	0.176	1.00	1.00	4.00
Oscar Almendare	.67	0.55	0.048	1.00	1.00	4.00
Mike Belset	1.44	1.47	0.368	2.00	2.00	1.00
Nicholas Mahtes	1.47	1.39	0.316	2.00	2.00	1.00
Anthony Gentile	2.87	2.87	1.000	2.00	1.00	2.00
Dan Forkio	2.32	2.23	0.667	2.00	1.00	2.00
Rory Campbell	2.15	2.27	0.750	2.00	2.00	1.00
James Cazzaina	1.37	1.31	0.300	1.00	1.00	4.00
Alex Folera	2.15	2.24	0.692	2.00	2.00	1.00
Nichole Willbur	1.20	1.29	0.188	1.00	2.00	3.00
Dan Lehto	1.14	1.07	0.238	1.00	2.00	3.00
Scott Barrows	1.16	0.96	0.111	1.00	2.00	3.00
Kevin Johnson	1.88	2.00	0.556	2.00	1.00	2.00
Omar Vasquez	1.30	1.19	0.222	1.00	1.00	4.00
Jason Schlegel	2.17	2.41	0.769	2.00	1.00	2.00

Name	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	CR1	CR2	CR3	CR4	CR5	CR6	CR7	CR8	CR9	CR10
Peter Fallon	9	8	7	4	7	8	5	4	10	2	9	7	9	2	6	6	7	4	8	9
Thomas Morin	5	8	8	4	8	3	1	7	4	7	7	9	9	7	9	5	7	8	5	8
Nick Merolla	9	9	10	10	10	7	8	8	7	7	9	4	8	6	6	7	4	5	6	6
Ashley Pulin	7	3	10	4	8	5	4	9	9	2	9	6	9	7	5	6	9	10	9	10
Mike Mastroria	10	10	6	5	5	7	6	5	8	7	4	10	6	10	5	7	5	7	8	2
Mike Manning	7	7	6	6	3	7	5	4	2	10	10	10	10	10	5	7	7	8	8	10
Brian Foley	9	9	9	9	10	6	5	9	8	10	10	10	10	8	7	7	9	8	10	8
Oscar Almendare	3	4	2	4	10	1	1	1	1	1	1	1	2	1	2	3	1	1	1	2
Mike Belser	5	8	7	6	3	9	5	7	4	6	10	6	7	9	8	7	4	8	9	9
Nicholas Mahtes	10	9	8	8	6	7	9	8	7	9	10	10	8	7	6	6	8	8	9	10
Anthony Gentile	10	4	9	1	5	2	8	7	6	3	5	2	8	3	6	10	9	7	4	1
Dan Forkio	7	4	8	2	2	8	5	8	10	5	10	4	6	3	7	8	7	5	9	3
Rory Campbell	7	2	2	4	3	5	4	7	5	1	2	4	1	9	6	7	5	7	10	6
James Cazzaina	4	4	6	5	5	5	7	2	6	9	8	7	7	9	6	7	8	5	5	9
Alex Folera	4	3	4	8	3	4	2	4	6	5	4	8	5	3	1	8	9	4	7	6
Nichole Willbur	4	5	8	4	8	9	10	7	7	6	7	6	8	8	10	10	10	10	10	7
Dan Lehto	6	9	4	9	6	3	5	7	1	5	6	8	6	7	9	5	8	7	7	6
Scott Barrows	3	5	10	5	10	8	4	5	7	10	10.	10	10	7	10	8	10	10	6	10
Kevin Johnson	5	6	5	7	6	8	4	3	1	5	7	7	6	5	7	9	4	3	9	10
Omar Vasquez	9	6	5	7	4	8	7	2	8	4	6	7	6	7	8	5	7	4	7	4
Jason Schlegel	7	2	4	3	1	2	10	8	5	3	1	7	4	8	3	7	4	5	9	10

Appendix H

Teacher Evaluation

Teacher Evaluation

Please rate the student in the following categories: (5 being the best)

Preparedness

1 2 3 4 (5)

Presentation

1 2 3 4 (5)

Please rate the class lessons in the following categories: (5 being the best)

Content

1 2 3 4 (5)

Practicality

1 2 3 (4) 5

Do you feel the students learned the material better when it was taught in this fashion? (historical and social context)

IT GAVE THE STUDENTS AN ABILITY TO RELATE PAST AND PRESENT EVENTS

Would you use this curriculum of teaching science and technology with historical and social context in future classes?

YES, WE WILL INCORPORATE THIS INTO NEXT YEARS ROBOTICS CURR.

Was there any section of the unit that you did not particularly like?

all WAS INTERESTING AND THE KIDS PARTICIPATED. IN most all DISCUSSIONS

Please use this page to write any additional comments.

Mr Hudson did a great job presenting the material. The students were interested and seem challenged. The curriculum was well researched and presented in a fashion so that the students were involved in all discussions. It was a pleasure to have Mr Hudson present his IQP project to the students a Doherty H.S and would welcome future WPI involvement in our pre engineering course starting Fall of 2000

Thx TF Carter

Appendix I

Sample Feedback

Design Project

Now that your group has designed a robot to complete a certain task, you are now to debate the social aspect of this robot. In other words, is this robot best designed for this work? Or is there no need for a robot here, a human can do the job? Discuss this idea below and be sure to include the welfare of the people whose jobs the robot replaced, as well as the jobs that are created by implementing a robot.

The job that the robot does, cleaning the nuclear power plant, could be done by a human. However it is far safer to have the robot do the cleaning, since the nuclear waste is extremely hazardous to human health. Not many people would want to clean nuclear waste, no matter how much they would get payed. Someone would need to supervise the robot, because a robot is not a human and it can make mistakes.

HOMEWORK
History of Robotics

NAME: Scott Barrows

1. What does the word 'robota' in Czechoslovakian mean?

Forced Labor

2. What was society's attitude towards robots during the 1920's?

Their Social attitude towards robots was not good.

3. How many laws of robotics did Isaac Asimov have?

1 A robot may not injure a human being, or, through inaction, allow a human being to come to harm.
2 A robot must obey the orders given it by human beings, except where such orders would conflict with the first Law. →

4. In what type of factory was the first industrial robots used in?

Car factoryes for welding moving heavy parts.

5. Did you enjoy the history lesson? Do you feel history is important to learning?

Yes I did enjoy this history lesson. I also believe it is very important to learn about history which shows us what the world went through to get where we are ~~today~~.

6. Do you feel you learned valuable information about robots?

Yes I did learn valuable information about robot and what jobs they do and how it has improved over the years of technology.

(3)

3. A robot must protect its own existence, except where such protection would conflict with the first or Second Law.

Design Project

Scenario:

Group is to design a robotic arm, which is attached to a submersible vehicle, which is used for exploration of shipwrecks.

Requirements:

Your group will need to have a drawing of your robot design, as well as a list of characteristics

a. Type of end effecter used and why?
b. Type of power supply and why?
c. The robot configuration and work envelope used.
d. Is the robot fixed or mobile?
e. Is the robot servo or non-servo?
f. Is the robot industrial or non-industrial?

Also for each characteristic, an explanation is need as to why the choice that you selected is better than the other options.

a. You would want to use a claw like effecter because it is capible of grabbing large, small, and werd shaped objects

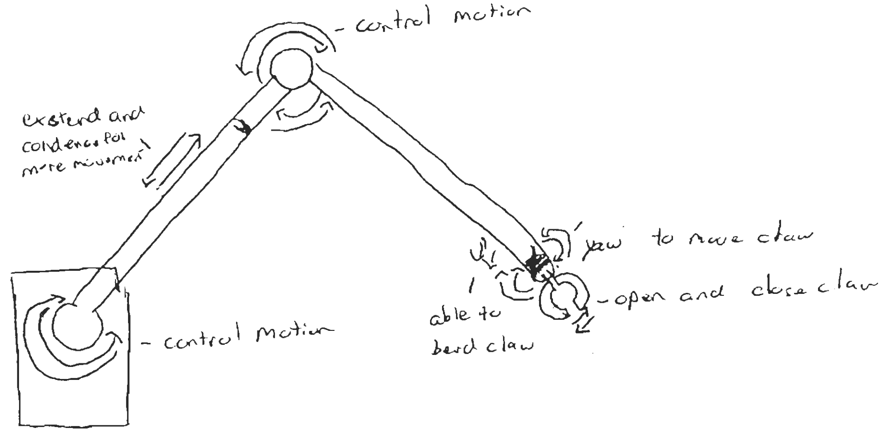
b. You would want to use electric because it is strong and will not effect the enviroment under water. It would have to be protected though.

c. Jointed Arm Coordinate Robot because it can move better in this situation than any other robot and it would be strong enough to work under water.

d. Mobile because you do not know what to find under water and the aproach to grab it is different

e. A Servo because you need feed back and you need to control the ecact movements

f. Non-industrial because it does not need set points and will be used for different tasks.


- control motion
extend and
condence for
more movement
yaw to move claw
able to
bend claw
- open and close claw
- control motion