Cross-Curriculum Education and Robotics
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Today's science classroom is increasingly becoming limited through budget cuts in struggling school districts and the lack of qualified teachers to fill open positions. Vernon J. Ehlers, Chairman of the US Committee on Environment, Technology and Standards stated that "a Hudson Institute estimate[s] that 60% of all jobs in the early 21st century will require skills possessed by only 20% of the current workforce.[1]" In short, the nation is not educating enough scientists to handle the expected needs of the future. Given that the United States is a world leader in the area of technology as evidenced by the contributions from Silicon Valley, major biotechnology concerns, and successful NASA space missions, ways must be developed to incorporate more science education into contemporary classrooms.

This paper will attempt to illustrate how science and technology in the form of robotics education can be introduced into the science classroom through the selection of astronomy as the core curriculum addressed. The rationale for attempting such inclusive education, a description of the method of delivery, suggested cross-curriculum links, and a suggested lesson will also be discussed. The goal of this paper is to show that scientific technology can be implemented effectively in today's existing classrooms, and that such topics as robotics can be discussed in the classroom whether or not the teacher has access to hands-on equipment.

Currently, NASA has an extensive Robotics Education Project that allows teachers to have access to cutting edge curriculum at the click of a mouse button.[2] Information is available from NASA on all the major missions, planets, celestial phenomena and mathematics useful in understanding key astronomy concepts. Since a huge amount of information is already available and current robotic missions are either currently underway or planned in the near future, introducing students to scientific technology through the avenue of robots in space is one that is both timely, informative, and well within the reach of any motivated teacher.

The current statistics on educational procedure in today's classrooms reveal that little if any time is spent on science and technology. A study by Horizon Research, Inc. conducted in 2000 attempted to quantify the quality of education provided in the K-12 grade range.[3] The data below is a sample of the statistics obtained from the Horizon study. Percents are meant to include the

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1Statement of Vernon J. Ehlers, Chairman Subcommittee on Environment, Technology, and Standards, House Science Committee Field Hearing: Workforce Training in a Time of Technology Change. Saginaw Valley State University, Saginaw, Michigan. June 24, 2002. http://www.house.gov/science/hearings/ets02/jun24/ehlers.htm

2NASA Robotics Education Project. http://robotics.nasa.gov

percentage of time each category or type of science education listed took up from the total science curriculum presented to students.

Table A: Percent of Science Education by Type

Type of Science Lesson	Grades K-5	Grades 6-8	Grades 9-12
History and Nature of Science	2%	0%	4%
Earth and Space Science	24%	27%	8%
Science and Technology	2%	0%	3%

The Horizon study was conducted by observing classroom time spent on various types of scientific education. Researchers also stated, "The prevalence of life and Physical Science lessons at the high school level mirrors patterns of course offerings reported in the 2000 National Survey of Science and Mathematics Education, where three-quarters of courses are classified as either life or physical science. The percentage of lessons with a focus on science inquiry (typically in combination with another topic) varies from 2 percent of lessons in grades 9-12 to 15 percent of lessons in elementary school.[4]" Statistics like these illustrate that school children in the United States are not being offered complete, compelling or competent educational opportunities in the areas of science and technology despite the fact that these are at the forefront of many major fields of study needing qualified workers.

The theory under which this paper is conceived is that by combining subject matter, it is possible to even out the time spent on these three major science subcategories, thus enhancing the quality of scientific education received by today's students. It is the belief by this author that science and technology are within the reach of motivated teachers, and that such incorporation of that educational opportunity can be achieved without the need of expensive equipment. As stated earlier in the Horizon Research, Inc. report, 0% of students in grades 6-8, the middle school years, were receiving any science or technology lessons at all in their typical science classes. This translates into students not receiving the message that such careers are worthy of their consideration. Students are also not pursuing enough mathematics or higher sciences when they reach high school, and when they do, as the Horizon report shows, only about 8% of them receive any Earth and space science.

The Third International Mathematics and Science Study revealed that 4th graders were found to be above average in math, but that by the 8th grade, US students had fallen an entire grade level behind, and by 12th grade, US students were only able to score higher than students from the countries of Cyprus and South Africa from a list of 41 countries surveyed.[5] The National Center for Educational Statistics in the statement from the Commissioner states that “post secondary

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3 Iris R. Weiss, Joan D. Pasley, P. Sean Smith, Eric R. Banilower, Daniel J. Heck *Looking Inside the Classroom:A Study of K-12 Mathematics and Science Education in the United States*. Horizon Research, Inc. May 2003. http://www.horizon-research.com/insidetheclassroom/reports/looking/chapter3.pdf

4 Horizon Research, Inc. *Looking Inside the Classroom: A Study of K-12 Mathematics and Science Education in the United States; content Focus of Observed Lessons*. May 2003. p. 22.

5 Education World. *Third International Mathematics and Science Study*. 27 April 98. http://www.educationworld.com/a_curr/curr071.shtml

institutions provided remedial coursework for 28 percent of entering freshmen in fall 2000....Public 2-year colleges provided such coursework for 42 percent of their entering students.”[6] The fall-off in mathematics education parallels the Horizon study on Science and

Technology stated earlier and reinforces the fact that once the system fails to provide an adequate education for its students, the effects spiral downward. The numbers of students attending college who require remedial classes is high, and is a further symptom of the current state of math and science education.

It is clear that one of the reasons that America is not fulfilling its need to teach future scientists is that it is not providing the necessary introductory education. The failure to inspire students early on is further compounded at the secondary and college levels. Failure to capture the collective imaginations of students when they are young and building the appropriate educational bases for their future collegiate career bears a direct and detrimental effect upon their ability to choose technological careers for their future.

Time is pressing in many contemporary classrooms, however, through the use of crosscurriculum techniques many lessons can be taught while at the same time addressing several educational standards at once. Cross-curriculum education is not new to the contemporary classroom. Many of today's current textbooks offer supplemental materials and resources to bridge the cultural, subject matter, or gender boundaries. In the scenario projected in this paper, we are attempting to show, as an example, how scientific technology can be introduced into a classroom while studying the necessary concepts provided in astronomy. It is possible to include history of major astronomical discoveries such as Johannes Kepler's discoveries regarding the elliptical orbits of the planets, or Newton's Universal Law of Gravity. Such concepts apply to Earth, but students can also learn that they also apply to the other planets as well. Reading about robots and astronomy, even in the form of science fiction, can encourage students to read for pleasure and knowledge. If teachers carefully choose the supplemental reading they allow students to access, important information can be offered to students. Even art can play a role in the science and technology classroom as students design robots to travel to distant planets.
Speculation on what the outer realm of our universe might look like, what laws are obeyed by the objects that orbit there, and how robots might aid in the collection of future data are all topics easily discussed in the classroom setting using contemporary, inexpensive, and publicly available information.

Provided below is a suggestion for a lesson incorporating the subject areas of mathematics, science history, astronomy, Earth science, robotics and technology into one project. Since the age group most neglected in science and technology as identified by the Horizon study is the 6-8 grade level, this lesson is aimed for this age group.

Mission to Planet Z

Assumptions:

- Students will work in small groups of 4-5 students.
- This project has several components and is done over an extended period of time.
- Students will have studied Earth as a planet member of our solar system. Teachers may review the essential facts to guarantee availability of essential knowledge to entire class.

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6 National Center for Educational Statistics. *Commissioner's Statement*. http://nces.ed.gov/programs/coe/statement/s7.aspè

Scenario:

- Students will be comparing the Earth to one of the other inner planets.
- Teachers can assign a planet based upon student interest.

- Students are informed that they are going to plan a mission to visit an inner planet. They are to compare this planet to what they know about Earth. The mission will be to deliver a robot to study the planet. The following information will be required:

Phase One:

- History of who discovered the planet.
- Statistics on the planet as compared to Earth.
- Students will assemble a two-column list of attributes labeled “Same” and “Different”. Under these headings they will sort data about Earth and their planet into the appropriate column. For instance, if they discover that both planets have seasons, they would indicate this under the “Same” category, while an attribute like gravity would be recorded under the Different” category.
- Description of the planet's atmosphere, composition, orbital period, temperature, etc. will be written on cards to be placed upon a group poster.
- Students will prepare a group poster about their planet and share will the entire class. Artwork, bibliography and rough drafts will be turned in by each student to document their participation in Phase One.

Phase Two:

- Discussion of robots and what attributes a robot must have to make a successful mission to another planet. NASA's Robotics Education Project can be accessed here for ideas.
- Students list the tasks they want their robot to complete during its mission.
- Students compare the attributes of the assigned planet and describe any limitations expected by the robot while on its mission. Questions to be considered might include:
- Is the planet so hot the robot might melt? So cold it might freeze and refuse to operate?
- Should the robot remain in orbit to do its mission? Should it contact the surface? How?
- What are the dangers to a robot? What will it have to sense in order to remain safe?
- What are the advantages to sending a robot to the planet? Why not humans?
- Has NASA sent a mission to this planet already? What was discovered?
- Does NASA plan on visiting this planet again? When? What do they plan to study?
- Students draw up a final mission and present to the class for comments or suggestions.

Phase Three:

- Using common household discards like bottles, straws, paper towel tubes, newspapers, cardboard, paper, wire, meat trays, and other materials, students build a model of their robot for presentation to the class.
- Students prepare a final mission report as though their robot has already been to the planet in question.
- Students prepare a list of questions that they feel have not been adequately addressed by past missions.
- NOTE: This project can be expanded in the following ways:
- Essential scientists who made discoveries in supporting mathematics or physics can be included in teacher discussions with an emphasis upon the need for others to take an interest in studying these topics and the importance of mathematics to space travel and discovery.
- Historical coincidences such as literary evidences of comet sightings or discovery of planet information as recorded by Galileo, Tycho Brahe, Copernicus, Newton, Ptolemy and others can be included by teachers to introduce a history strand into the curriculum.
- Current event logs from newspaper readings regarding space phenomena, astronomy, mathematics, science, robotics, and technology can be introduced by the classroom teacher as a reading component that is directly related to the science strand. Such a log

would encourage students in the practical knowledge that such careers are possible and which skills are useful in acquiring these occupations.

- If the school has a computer lab with Internet access, introduce the students to the NASA Robotics Education Project website and assign readings and explorations from the website to be shared with the class.
- Mathematics formulas using simple algebraic principles and related to planet orbits, distances from the sun, density, gravity, temperature conversion, etc. can be introduced to the students and calculated for all the planets in the terrestrial group.
- This project can be repeated for the outer Jovian planets for double the fun and double the consideration of the material covered.

It is very apparent that the current state of education in the US does not meet the needs of students in mathematics, science and technology. It is also known that there is a projected deficit between the number of available careers and the number of qualified personnel to fill those positions in the very near future. America must change its educational methods to provide a more robust and comprehensive format for her children to make the effective and competitive in the world marketplace. Through the use of cross-curriculum educational methods teachers can provide a more comprehensive and connected education for their students; and through the use of already existing government assets, such as the NASA Robotics Education Project, teachers can implement a cross-curriculum program with relatively little additional cost. By introducing students to the combined subject matter, as in the case of the Mission to Planet Z project, the foundation is firmly established as to the links between mathematics, science, technology, robotics, astronomy, and Earth science. Students have the opportunity to see the link between history, current events and future explorations. Today's students, through the use of crosscurriculum educational methods, come away from their primary and secondary education ready for challenging collegiate curriculum that will finish educating them on pathways set down and planned for in their earlier educational endeavors. Waiting until college to address remedial skills wastes valuable educational resources and time. Preparation must begin in the earlier grades by engaging students to prepare themselves for the mission of a lifetime: employment in the fields of science and technology.[7]

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7 Becky Ann Sherman is a senior at California State University at Hayward. She is pursuing a teaching credential in middle school mathematics, has served as a Botball mentor for 6 years, and is currently active in community outreach efforts to assist students with learning disabilities through the use of cross-curriculum methods, including teaching mathematics concepts through the use of robotics technology.