Robotics in School – the Use of LEGO Robots in the Classroom to Attract Students to STEM Areas of Study

by

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Robotics in School – the Use of LEGO Robots in the Classroom to Attract Students to STEM Areas of Study

A Thesis Proposal by

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March 13, 2009
Objective

The objective of this research is to assist a number of teachers in local schools, to facilitate the improvement of lesson plans incorporating robotics. This will include assisting teachers with new software components and lesson plans to support their use in local schools. These components will be used with a kit of First robotics parts to develop in-class applications for robotics, in the hope of attracting more students to STEM areas of study.

Problem Statement

In the United States, university enrollment for science and engineering degrees has been increasing very slowly over the last decade. However, interest in certain science and engineering areas, specifically engineering and computer-science related fields, dropped sharply between 2000 and 2004 [11][6][13]. Low student enrollment in science and engineering has been a concern since the 1990s. Though the numbers are slowly increasing, the number of American and Western European students in universities who are pursuing degrees in science, technology, engineering, and mathematics (“STEM” areas) is much lower than it needs to be, especially among women and ethnic minorities [6].

Science, math and technology are integral to the safety and economic health of any country [8]. One example of this importance can be seen in modern warfare, which depends on encryption systems to secure personal and government data, new advances in weapons and defense systems (such as software-based security systems or radar), new mechanical designs for troop transportation, and materials’ design for armor. Economically, as firms shift their business to offshore sites (and many low-level engineering and science jobs at the same time), there is a growing need for highly qualified employees at company headquarters, who can provide the initiative and ingenuity to keep the companies competitive in the development arena, as well as in cost-saving measures [6].

While the engineering and science community has tried to attract more women and minorities into STEM-related areas, the number of women and minorities in many science and engineering fields has not increased substantially over the last 5 years. In 2005 69% of undergraduate students in the United States were White. By the year 2050 the United States’ college-aged population has been forecast to consist of only 48% white students, with the other 52% made up of Hispanics, Asians, African-Americans, and other minorities. This trend in population makes it more important than ever that women and minorities be brought into STEM related fields, as the percentage of the population that stereotypically has held those careers (usually white males) decreases over the next 40 years [13][3]. Unfortunately, the current number of women and minorities enrolling for most Science and Engineering degrees remains much lower than the percentage of ethnic and female students in the relevant college communities.
The low number of women and minorities in Science and Engineering fields does not seem to be caused by any particular inability to grasp scientific concepts, but rather a disinterest in the topics available in those fields [8]. Female students, for instance, tend to have a more social outlook than male students do. While men dominate most engineering fields in American universities, in 2004, 78% of Bachelors’ degrees awarded for Psychology in the United States were awarded to women [13]. In the same way, when assigned science-related task, male students are usually content with a simple task (“build a car with Lego’s”), female students prefer assignments that have a defined purpose. What is the car for? How fast should it go? Does it need to fit into a garage of a certain size? [9]. Unfortunately, while students as young as 2nd graders can grasp the concepts of algorithms and scientific testing, by the end of high school many of them have become “turned off” to science and engineering [5][9].

This students’ apathy toward STEM-related fields may be influenced by many factors, including teachers’ attitudes toward these subjects. Though they have taken science classes themselves, many education majors (especially those majoring in childhood education, which incorporates a variety of subjects, rather than a single specialized focus) do not have much experience in math and science, which can lead to low confidence in their own ability to teach science and math courses. This lack of confidence, when paired with the pressure to teach to standardized tests (which decrease the amount of class time that can be given to hands-on scientific discovery), can result in a presentation of science and mathematical studies as both hard and uninteresting [8]. Sources of discouragement for older students may include the stereotypes of engineers and scientists, especially those that peg them as nerdy males with deficit social skills. Degrees in science and engineering also have a reputation for being very difficult, since required classes are highly structured and often don’t have room for student-broadening experiences such as travel abroad or concentrations and minors that appeal to students’ personal interests [6].

Background

Since the early 1990’s, universities and corporations have been developing ways to encourage young students to consider engineering and sciences as a potential career path. One of the most popular methods of reaching students in the K-12 grade range has been through the use of outreach programs: lessons and workshops conducted or supported by outside faculty (often University Faculty members) or older students. These outreaches assist teachers who may be struggling to convey STEM-related topics to their students in a relevant way, and give students a chance to experience lessons that are both broadening and interesting. Because most outreach projects involve multiple parts (designing, building, testing, and then presenting the students’ results), they also give students an opportunity to use skills from multiple subjects to complete one project.

Outreaches to local schools take on many forms. While some, like First Robotics competitions are primarily extracurricular activities, others (which this project will focus on) are held directly in the classroom, during class time. Many outreaches contain some
element of study, as outreach facilitators adjust their curriculum to be more relevant to student interests and studies, based on responses from teachers and students.

One of the hardest things to teach young students is how to take a generalized approach to problems. Rather than understanding the overall concept of how to solve a given class of problems, young students will often memorize the solutions to specific problems and then regurgitate the answers when tested. A good understanding of algorithms (the steps that must be taken to get from point A to point B) is valuable not only for solving homework problems in math and science classes, but also outside of class, in any situation when students need to solve an unfamiliar problem [5].

On this premise, an exploratory program was held by a faculty member at Tufts University, with the purpose of teaching algorithms to local 2nd grade students. After an initial test, workshops for were held for each of 4 classes every week for one school year. Each workshop included elements of math and computer science, both fields that rely heavily on students’ understanding of algorithms. At the end of the year a second test was administered to measure the improvement in the students’ ability to use and recognize algorithms. Workshop lessons included instructions for making origami frogs, playing number-guessing games with the teacher, and analyzing the code behind a spell-checker program. Though project topics were centered on computer science and math, the workshops included elements of writing and teamwork, as students in the class learned to keep journals, and discussed the puzzles they were presented with before tackling them as a group. Though some of the final tests were inconclusive, students showed an improved ability to recognize and create algorithms by the end of the year [5].

The usefulness of outreaches stems from the fact that they are hands-on. While students in a typical earth science class are limited to rock testing on lab benches, students working with relevant and interesting hands-on projects are more likely to retain what they have learned in the course of a project. Kindergarteners building Lego walls, for instance, will learn to create structurally sound designs when their previous designs fail a drop test; without the drop test, they would keep using the same faulty building methods, no matter how many times the teacher told them to correct it [9].

Since students are most interested by math and science lessons that involve active exploration, robotics have proved to be a very attractive learning platform for students participating in technology or outreach programs [9]. LEGO robotics especially have proved to be highly useful in the outreach arena, since they are versatile enough to be used in lesson plans for students with ages ranging from kindergarteners to University students [4][2][9]. LEGO robotics kits are commercially available and designed for hobby robot design. This means that the kits are relatively inexpensive (at about $250 per kit), and designed with simplicity, for easy use by amateurs. Each kit contains a central microcontroller brick (commonly referred to simply as the “brick”), which can be programmed with Robolab, a programming environment that uses a simplified version of LabView code. Specialized LEGO pieces are used to build a robot around the brick, which has the ability to take input from as many as four sensors and power up to 3 motors.
Sensors made by LEGO include the following: A sound detector, which registers surrounding noises in decibels; an ultrasonic sensor, which measures the distance that the robot is from a given object; a touch sensor, which recognizes pressure placed on it; and a light sensor, which can be used to steer towards or away from light or dark areas. The brick can be programmed from the main computer with the use of either a USB cord or a wireless Bluetooth connection. Once programmed, the microcontroller is disconnected from the computer that the program was written on, and the program can be started directly from the brick.

This Project

It has been theorized that the best way to interest students in STEM areas is to give them hands-on experience. However, most elementary and high school teachers do not have the necessary knowledge to integrate programming and robot design into their classes. With our support, they can begin using robotics in lesson plans that have already been planned (creating a testing robot to test the PH of a fish tank, for instance), thus adding depth to the original lesson plans and hopefully increasing interest in core classes that relate to STEM areas of study. It is our belief that the use of commercially available hobby robots in the classroom can lead to the development of lesson plans that promote student interest in STEM areas, especially among women and minorities.

To facilitate the use of robotics in local classrooms, we will be assisting a number of teachers in local schools, to facilitate the use and testing of lesson plans incorporating rigorous and relevant use of robotics technology. Tasks will include assisting with lesson design, helping with software development, implementing lessons in class, and analyzing the results afterwards. The hope is that these components, when used with a kit of First robotics parts, will increase student understanding of and interest in STEM areas of study.

Some Robolab software will be developed by us outside of the classroom, for use with the Lego robotics kit. This will consist predominantly of support components, such as those used for data transfer. One possible component to be developed is a Bluetooth connection module, which will make it easier for students to connect the main computer to the brick wirelessly. Other software may be developed in the classroom by the students. This will be primarily behavioral software; programming the robot to do a specified set of tasks, rather than adding to the available software blocks in Robolab. This approach will give students exposure to elementary programming technology and tools, and give teachers without expertise in programming the assistance they need to make use of these tools in the classroom.

The first step will be to help teachers develop lesson plans to use these tools in the classroom. Our goal is to focus our work specifically on assisting local teachers who have already shown an interest in adding robotics to their normal lesson plans. A group of local teachers participated in a robotics workshop at Clarkson University this past
summer (summer of 2008). Examples of completed lesson plans can be seen in the Appendices located at the end of the paper. Participating teachers learned to use Lego Robots, program them, and use them to formulate lesson plans. One of the tasks for this thesis will be to help interested teachers who took this workshop to move their lesson plans from paper and into the classroom.

All projects completed in the course of this research will be determined and planned by local teachers, and will correlate with current learning topics based on state and federal standards. Rigorous pre- and post-testing procedures (developed with the help of each teacher) will be used to assess the effectiveness of these lesson plans and their content. This assessment will be done with statistical analysis, and will specifically examine the ability of these lesson plans to attract students to STEM areas of study. One way to trace the amount of interest generated by the lessons is by tracking the number of students taking STEM related electives after experiencing these lesson plans. In the long-term, the number of graduating students who enter STEM areas of study at the University level can also be tracked. The timeline for this project is as follows.

**Timeline:**
- **March 2009:** Get Thesis proposal approved
- **April 2009:** Advertise among local schools to find teachers to work with in the fall
- **Summer 2009:** Make initial contact with teachers, become more comfortable with Robolab and the Lego platform, organize approach for fall work
- **Fall 2009:** begin work with local teachers. Help perfect lesson plans incorporating robotics, present in class, and receive feedback afterwards. Keep proper documentation for the sake of thesis and further research.
- **October 2009:** Have Preliminary thesis done
- **December 2009:** Submit Thesis first draft
- **March 2010:** Thesis final draft due, oral presentation

To date we have run though one cycle of lesson development at a local school. Sharon Burl is a math teacher at the High School in Brasher Falls, NY, and was a participant in one of the summer workshops held at Clarkson University. During a unit on graphs, she decided to use one of the lesson plans she developed over the summer, and instituted a bridge-crushing contest in her class, using a Lego brick microcontroller to control the crusher. Bridge crushing is not usually associated with graphs, but the crushing apparatus used in her classroom included a stress gauge that output data to the Lego brick. These data points were output to a laptop and then graphed on the classroom smart board to display the relationship between the action of the crusher on the bridges and the graph produced by the gauge. In this way, Sharon’s students learned not only about math and graphs, but also about the physics involved in building a stable structure, and the response of different types of materials to stress.


APPENDIX A

Example of an Elementary School Lesson Plan

Title of Learning Experience:
Survive an Antarctic Night

Author:
Jeanette Burns

School District:
Lisbon Central School

Intended Audience:
Content Area: Science

Course Title: 5th Grade Science

Grade Level: 5

Technology Integration:

Technology Hardware: 6-7 NXT base units, 6-7 computers, 6-7 temperature probes

Technology Software: Robolab with program for sampling temperature change

Internet Resources:
http://astro.uchicago.edu/cara/vtour
http://www.coolantarctica.com
http://www.globalclassroom.org/antarct8.html
http://www.antarcticconnection.com/antarctic/weather/survival.shtml
http://www.usatoday.com/weather/resources/askjack/ajckicel.htm
http://wikipedia.org/wiki/sleeping_bag
http://www.survivaltopics.com/survival/sleeping-bag-insulation/
http://www.slackerpacker.com/sleepingbag.html

Other Content Areas for STEM Integration:

Content Area: Math, ELA
New York State Learning Standards and Performance Indicators Addressed by this Learning Experience:
Include the full wording of the standard(s) and specific performance indicator(s).

STANDARD 1 Analysis, Inquiry, and Design--MATHEMATICAL ANALYSIS:
Key Idea 3:
Critical thinking skills are used in the solution of mathematical problems.
M3.1 Apply mathematical knowledge to solve real-world problems and problems that arise from the investigation of mathematical ideas, using representations such as pictures, charts, and tables.
M3.1a use appropriate scientific tools to solve problems about the natural world

STANDARD 1 Analysis, Inquiry, and Design SCIENTIFIC INQUIRY:
Key Idea 1:
The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process.
S1.1 Formulate questions independently with the aid of references appropriate for guiding the search for explanations of everyday observations.
S1.1a formulate questions about natural phenomena
S1.1b identify appropriate references to investigate a question
S1.1c refine and clarify questions so that they are subject to scientific investigation
Key Idea 3:
The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into phenomena.
S3.1 Design charts, tables, graphs, and other representations of observations in conventional and creative ways to help them address their research question or hypothesis.
S3.1a organize results, using appropriate graphs, diagrams, data tables, and other models to show relationships
S3.2 Interpret the organized data to answer the research question or hypothesis and to gain insight into the problem.
S3.2a accurately describe the procedures used and the data gathered
S3.2b identify sources of error and the limitations of data collected
S3.2c evaluate the original hypothesis in light of the data
S3.2d formulate and defend explanations and conclusions as they relate to scientific phenomena
S3.2g suggest improvements and recommendations for further studying
S3.2h use and interpret graphs and data tables

STANDARD 2—Information Systems
Students will access, generate, process, and transfer information, using appropriate technologies.
Key Idea 1:
Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.
1.1 Use a range of equipment and software to integrate several forms of information in order to create good-quality audio, video, graphic, and text-based presentations.
1.4 Collect data from probes to measure events and phenomena.
1.4a collect the data, using the appropriate, available tool
1.4b organize the data
1.4c use the collected data to communicate a scientific concept

STANDARD 6—Interconnectedness: Common Themes
Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.
Key Idea 6:
6.1 Determine the criteria and constraints and make trade-offs to determine the best decision.
6.2 Use graphs of information for a decision-making problem to determine the optimum solution.

STANDARD 7—Interdisciplinary Problem Solving
Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

Key Idea 1:
The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomena.

1.4 Describe and explain phenomena by designing and conducting investigations involving systematic observations, accurate measurements, and the identification and control of variables; by inquiring into relevant mathematical ideas; and by using mathematical and technological tools and procedures to assist in the investigation.

Key Idea 2:
Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.

2.1 Students participate in an extended, culminating mathematics, science, and technology project. The project would require students to:
  -- Working Effectively: Contributing to the work of a brainstorming group, laboratory partnership, cooperative learning group, or project team; planning procedures; identify and managing responsibilities of team members; and staying on task, whether working alone or as part of a group.
  -- Gathering and Processing Information: Accessing information from printed media, electronic data bases, and community resources and using the information to develop a definition of the problem and to research possible solutions.
  -- Generating and Analyzing Ideas: Developing ideas for proposed solutions, investigating ideas, collecting data, and showing relationships and patterns in the data.
  -- Common Themes: Observing examples of common unifying themes, applying them to the problem, and using them to better understand the dimensions of the problem.
  -- Realizing Ideas: Constructing components or models, arriving at a solution, and evaluating the result.
  -- Presenting Results: Using a variety of media to present the solution and to communicate the results.

STANDARD 4: The Physical Setting

Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Key Idea 4:
Energy exists in many forms, and when these forms change energy is conserved.

4.2 Observe and describe heating and cooling events.

4.2a Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature.

Problem Statement:
This should be posed as a problem that students will be addressing. This will be the focus of the learning experience.

You are traveling with a group in Antactica and will need to spend the night outside on the way to your designated research station. You will need to supply a sleeping bag as well as personal effects for this trip. How will you determine the best design and insulating material for your sleeping bag?

Essential Question:
This is one focus question that promotes inquiry based learning and allows for multiple solutions and processes.

**What insulation material will provide you with the best protection against a cold Antarctic night?**

**Learning Objectives:**
By the end of this learning experience students will be able to:

**Determine the best insulating materials to keep humans warm.**
**Investigate weather types and patterns in Antarctica.**
**Graph collected data to determine temperature drop over time.**

**Necessary Resources:**
List all materials that the teacher or students need to complete this learning experience.

**Textbook(s), Workbook(s):** none

**Reference Book(s):**

**Handout(s):** Activity direction sheet

**Other:** Lab participation rubric

**Steps for Implementing Learning Experience:**
List the actions that take place during this learning experience.

**Testing samples of insulation materials using NXT brick and Robolab**
**Testing product during building process**
**Graphing data from final product**

**Instructional Modifications:**
List all modifications to the classroom setting as well as those used to enhance learning for all students.

Extended time--afternoon studyhall-- for students who do not complete in allotted time.
Consulting teacher available during lesson

Extension activity--plan all of the supplies necessary for a trip to the Antarctic including clothing, shelter, food, emergency supplies, and transportation..

**Time used for Planning:**
Time spent without students to prepare.

Load programs onto student computers--1 hour
Collection of various insulating materials--1 hour total
Video clips or powerpoint of Antarctic weather and storms--5-6 hours
Create Lab participation rubric--1/2 hour
Create Activity direction sheet--1/2 hour

**Time for Implementation & Assessment:**
List each day that the learning experience occurs along with the timeframe of the day in minutes.

Prior to implementing this activity, the students will have already used the temperature probes to measure different temperatures of soil and water and graphed the results.
Prior to implementing this activity, the students will have studied a unit on Antarctica as part of a unit on Biomes and Ecosystems.

Day 1:
   a. Hand out direction sheet and review assignment with students--15 minutes
   b. Sort students into groups of 3--standard lab assignment size--2 minutes
   c. Give students a few minutes to discuss activity in groups--initial brainstorming and problem solving--5 minutes
   d. Review use of temperature probes and graphing using NXT brick and Robolab with a teacher demonstration--10 minutes
   e. Have students brainstorm ideas about materials to use, how to create a sleeping bag, review of NXT bricks and graphing, etc.--what materials do they need to find and bring to class tomorrow--6 minutes.

Day 2:
   a. Quick question and answer session related to the activity--10 minutes
   b. Students lab groups will begin testing insulating materials they have brought from home using temperature probes and NXT bricks
   c. Students work groups will assess the insulating quality of the materials they tested based on the temperature drop vs time graphing of data (combined b & c) 25 minutes
   d. Students will determine additional materials they may need to bring and test tomorrow and clean up work stations --3 minute

Day 3:
   a. Students will begin building a prototype of the sleeping bag (sized for a hand) that they will create to survive an Antarctic night --15-20 minutes
   b. Students will do a preliminary test of their prototype based on the temperature drop vs time model--10 - 15 minutes
   c. Students will determine any changes needed to their prototype and additional materials needed--5 minutes

Day 4:
   a. Students will make any changes needed to improve their sleeping bag design and build a final bag that will fit a hand. The bag must have a covering, a lining and insulating material in the middle--38 minutes
   b. Students may wish to test their products or components again today.

Day 5:
   a. Students will test their sleeping bags outside (requires a cold day).
   b. Students will place one group member's hand in the sleeping bag and insert the probe in the sleeping bag "mitten"--30 minutes
   c. Students will download data to their computer workstation--8 minutes

Day 6:
   a. Students will use the collected data from yesterday to create a graph of temperature drop vs time--5 minutes
   b. Students will upload their graph to the student work folder--2 minutes
   c. Each students work group will share their sleeping bag design emphasizing the insulation used and collected data with the class--5 minutes X 6-7 groups--30-35 minutes

Day 7:
a. Graphs of student data will be compared to determine which bag retained heat the best (least
temperature drop vs. time)--10 minutes
b. The class will discuss which insulating materials worked best to maintain body heat--10 minutes
c. The individual students will write a short reflective piece detailing their experiments and results, how the
group worked together, and any changes they would make to their sleeping bag design--18 minutes
Note: full lab write-ups will be collected the following day for individual grades on project.

Assessment Tools:
List all forms of assessment for the learning experience.

Printed graph of temperature vs time data
Individual lab write up of activity--assessment will be based mainly on students’ conclusion section.
Lab participation grade from rubric.

Reflection:
Share the pros and cons of the learning experience. State any modifications that you would make next time
this lesson is implemented.

Student Work:
Attach one sample of student work that demonstrates a mastery, average, or below average level.

Rigor and Relevance Target:
The Rigor/Relevance Framework has four quadrants. Each is labeled with a term that characterizes the
learning performance of the student at that level. Select the quadrant that is most appropriate regarding this
learning experience.

<table>
<thead>
<tr>
<th>Quadrant C - Assimilation</th>
<th>Quadrant D – Adaptation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students extend and refine their acquired knowledge to be able to use that knowledge automatically and routinely to analyze and solve problems and create solutions.</td>
<td>Students have the competence to think in complex ways and to apply their knowledge and skills. Even when confronted with perplexing unknowns, students are able to use extensive knowledge and skill to create solutions and take action that further develops their skills and knowledge.</td>
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<th>Quadrant A - Acquisition</th>
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<td>Students gather and store bits of knowledge and information. Students are primarily expected to remember or understand this knowledge.</td>
<td>Students use acquired knowledge to solve problems, design solutions, and complete work. The highest level of application is to apply knowledge to new and unpredictable situations.</td>
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*From the International Center on Leadership in Education* @ [http://leadered.com](http://leadered.com)
This lesson is in quadrant D due to the following considerations:

1. The activity simulates a real world application of planning the equipment and supply needs for an group to explore the Antarctic.
2. The students must determine for themselves what materials they will test for insulation purposes.
3. The students must supply the necessary insulating materials based on their individual plans to create a sleeping bag capable of retaining heat in a cold environment.
4. The students will be analyzing the collected data to determine which type of bag and insulation works the best.
5. The students will be reflecting on their work and determining ways to improve on their results based on the results of their own tests and the other groups in the class.
APPENDIX B

Example of a High School Lesson Plan

Title of Learning Experience:
Hac

Author:
Jeffrey Buckingham

School District:
Madrid - Waddington

Intended Audience:

Content Area: Technology Education

Course Title: Robotics

Grade Level: 9 - 12

Technology Integration:

Technology Hardware: Acer Computer  NXT brick  Vernier dual range force sensor

Technology Software: Lego Robolab 2.9  Bridgebuilding/Structure DVD's

Internet Resources: West Point Bridgebuilder

Other Content Areas for STEM Integration:

Content Area: Physics  Mathematics

STEM PEER REVIEW PROCESS

New York State Learning Standards and Performance Indicators Addressed by this Learning Experience:
Include the full wording of the standard(s) and specific performance indicator(s).

NYS Standard #5 Technology
1. Engineering design is an iterative process involving modeling and optimization used to develop technological solutions to problems within given constraints.
   - locate and utilize a range of printed, electronic, and human information resources to obtain ideas.
   - develop plan, including drawings with measurements and details of construction and construct a model of the solution, exhibiting a degree of craftsmanship.
   - in a group setting test their solution against design specifications, present and evaluate results, describe how the solution might have been modified for different or better results, and discuss tradeoffs that might have to be made.

3. Computers, as tools of design, modeling, information processing, communication, and system control, have greatly increased human productivity and knowledge.
   - use computer hardware and software to draw and dimension prototypical designs.
   - use computer as a modeling tool.
   - use a computer system to monitor and control external events and / or systems.

4. Technological systems are designed to achieve specific results and produce outputs, such as products, structures, services, energy, or other systems.
   - describe how systems control requires sensing information, processing it, and making changes.

Problem Statement:
This should be posed as a problem that students will be addressing. This will be the focus of the learning experience.

We need to be able to devise a device used to determine the strength of a model bridge and apply data to real life situations.

Essential Question:
This is one focus question that promotes inquiry based learning and allows for multiple solutions and processes.

How may we utilize computer hardware and software with materials in the lab to test, record, and compare the strength of model bridges.

Learning Objectives:
By the end of this learning experience students will be able to:

Design and build a bridge testing structure.
Incorporate computer hardware in the structure.
Incorporate computer software to record tension on a bridge.
Use resulting data to compare different bridge designs.

Necessary Resources:
List all materials that the teacher or students need to complete this learning experience.

Textbook(s), Workbook(s): Engineering notebook
Reference Book(s): Engineering with Lego Bricks and Robolab
Handout(s): Problem solving steps. Bridge dimension limitations and constraints.
Other: NXT 2.9  NXT Brick  Lab construction materials

Steps for Implementing Learning Experience:
List the actions that take place during this learning experience.

**Introduce the subject of why we test products using modeling techniques.**

Introduce problem solving techniques.

Distribute handouts listing the problem with limitations and constraints.

Have students break into groups to brainstorm ideas.

Have students select the best solution.

Have students implement the solution by building their design and testing a model.

Have students evaluate and compare their results.

**Instructional Modifications:**
List all modifications to the classroom setting as well as those used to enhance learning for all students.

The task will be implemented and completed in the Technology lab, no modification necessary.

**Time used for Planning:**
Time spent without students to prepare.

Six to ten hours.

**Time for Implementation & Assessment:**
List each day that the learning experience occurs along with the timeframe of the day in minutes.

This learning experience will span fifteen days with a fortytwo minute period per day.

Day 1- Introduce the problem.
   Introduce problem solving techniques. Use examples.

Day 2 and 3- Model and discuss structure and bridge building theory.

Day 4- Have students brainstorm ideas and select the optimum solution.
Day 5 - Have students begin building the device.

Day 6-10 - Students will build and refine their project.

Day 11-14 - Students will be testing bridges and refining any hardware/ software problems

Day 15- Students will evaluate their design and data.

**Assessment Tools:**
List all forms of assessment for the learning experience.

Employ pretest- postest multiple choice tests pertaining to problem solving, engineering principles, and software application.

**Reflection:**
Share the pros and cons of the learning experience. State any modifications that you would make next time this lesson is implemented.

**Student Work:**
Attach one sample of student work that demonstrates a mastery, average, or below average level.
**Rigor and Relevance Target:**
The Rigor/Relevance Framework has four quadrants. Each is labeled with a term that characterizes the learning performance of the student at that level. Select the quadrant that is most appropriate regarding this learning experience.

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<td>Students use acquired knowledge to solve problems, design solutions, and complete work. The highest level of application is to apply knowledge to new and unpredictable situations.</td>
</tr>
</tbody>
</table>

*From the International Center on Leadership in Education @ [http://leadered.com](http://leadered.com)*

Provide Supporting Information to Validate the Quadrant in Which This Learning Experience is Located.

Students will be functioning in all quadrants culminating in quadrant four when they compare and evaluate how their device performs the task.