Affordable Robotics and Integrated STEM for ALL

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University of Georgia
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Why robotics?

• Can easily integrate with STEM learning
  • Not an “add-on”
  • Same content; new strategy
• Contextualizes content
• Enables real-world applications of STEM
• Motivates and increases interest
• Provides hands-on work to stimulate thinking of both girls and boys
• Good opportunities to integrate English language arts and social studies as well
Beginnings

• ETES 2320 Creative Activities for Teachers course
  • Undergraduate elementary ed majors
  • EIE, TeachEngineering, SAE World in Motion, ASEE eGFI, etc.

• Developed unit on robotics four years ago
• Using LEGO Mindstorms NXT kits
• Also have LEGO WeDo kits and EV3 kits
• Students constructed and programmed
• Developed lesson plans and posters
LEGO Mindstorms 9797
LEGO Mindstorms 9695
Student work & experimentation
Posters prepared
Completed robotics project
Presentation to visitors
Went well ... but

- Students learned about robotics
- Students learned basics of programming
- Students connected robotics to elementary education lesson materials
- Students made connections between robotics and STEM content
- Students gained confidence and increased self-efficacy
- **Students also asked and reacted to a difficult question**
The question ...

How much do these cost?
The reaction ... 

There is no way I will have the funds to purchase this!!
Quest for alternatives

• Explored SumoBots and VEX
• Also Arduino and Raspberry Pi
• My Robot Time used one semester

<table>
<thead>
<tr>
<th>Make</th>
<th>My Robot Time</th>
<th>Roborobo</th>
<th>Lego NXT</th>
<th>Lego EV3</th>
<th>Sumobot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcontroller</td>
<td>ATmega32A</td>
<td>ATmega8A</td>
<td>AT91SAM7S256</td>
<td>AM1808(ARM9)</td>
<td>PIC18F4550</td>
</tr>
<tr>
<td>Bit</td>
<td>8 CMOS</td>
<td>8 CMOS</td>
<td>32 ARM7</td>
<td>32</td>
<td>8</td>
</tr>
<tr>
<td>Memory (KB)</td>
<td>32</td>
<td>8</td>
<td>64</td>
<td>64MB</td>
<td>32</td>
</tr>
<tr>
<td>I/O</td>
<td>32</td>
<td>23</td>
<td>32</td>
<td>32</td>
<td>35</td>
</tr>
</tbody>
</table>
Roborobo

• Discovered Roborobo, a South Korean company, from a fellow faculty member
  • Purchased in South Korea for his son
  • Made contact and established ability to purchase in US
  • Also resulted in funded research and curriculum development project

• Level 1 kit allows building and programming of an autonomous robot
Key characteristics of Roborobo

• Easy to assemble
• Easy to program
• Does not look like a toy
  • Builds self-efficacy when learners succeed
  • Learners more serious when hardware looks like a real machine
• Economical (educational price approx. $75)
• Rogic software runs on PC only but free to install on as many computers as desired
Entire kit in 20cm x 15cm case
Assembled basic robot
IR sensors and LED lights
Simple to use programming
Curriculum development project

• Materials developed by *Research for the Advancement of Innovative Learning* (RAIL) team at the University of Georgia
• Funding provided by the Roborobo company of South Korea
• First unit designed for use in grade five classrooms
• Key theme is the engineering design process
• Context is exploration of an active volcano
• Decimals, measurement, and coordinate grids
• Elementary programming
A robot needs to collect samples from a dangerous environment. It has to collect samples from three sites and return to base.

THE ENGINEERING DESIGN PROCESS

1. Identify, Define, & Research Problem
2. List Requirements & Constraints
3. Develop Solutions
4. Evaluate Solutions
5. Construct Prototype
6. Evaluate Prototype
7. Modify Design & Produce Solution
8. Communicate Solution

YOU ARE AN ENGINEER!
### Overview of unit

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Name</th>
<th>Driving Question</th>
<th>Base Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Danger Zone</td>
<td>How can scientists study dangerous environments?</td>
<td>1 hour</td>
</tr>
<tr>
<td>2</td>
<td>Build-a-Bot</td>
<td>How do engineers build robots to accomplish specific tasks?</td>
<td>2 hours</td>
</tr>
<tr>
<td>3</td>
<td>Primary Programming</td>
<td>How can the basic movements of a robot be controlled using simple programming commands?</td>
<td>2 hours</td>
</tr>
<tr>
<td>4</td>
<td>Purposeful Programming</td>
<td>How can sequential movements of a robot be controlled using sequential programming commands?</td>
<td>2 hours</td>
</tr>
<tr>
<td>5</td>
<td>Prime Optimization</td>
<td>How can math be used to efficiently program a robot to perform a specific task?</td>
<td>1 hour</td>
</tr>
<tr>
<td>6</td>
<td>Share</td>
<td>How does the engineering design process help with problem solving?</td>
<td>1 hour</td>
</tr>
</tbody>
</table>
Design-based Research

Generic model for design research in education (McKenney & Reeves, 2012)
## Evaluation of unit

<table>
<thead>
<tr>
<th></th>
<th>Iteration 1: Pilot (2 classrooms)</th>
<th>Iteration 2: Field Trial (6 classrooms)</th>
<th>Iteration 3: Test Revisions (3 classrooms)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Analysis/ Exploration</strong></td>
<td>Establish viable framework for seamless STEM integration</td>
<td>Prepare for implementation</td>
<td>Prepare for implementation</td>
</tr>
<tr>
<td><strong>Design/ Construction</strong></td>
<td>Create and prototype teacher guide and student guide with 2 classrooms</td>
<td>Implement revised curriculum with 6 classrooms</td>
<td>Implement revised curriculum with 3 classrooms</td>
</tr>
<tr>
<td><strong>Evaluate/ Reflect</strong></td>
<td>Revisions focused on readability and flow of activities</td>
<td>Revisions focused on mathematical thinking and computer programming</td>
<td>Analyze data from each iteration</td>
</tr>
</tbody>
</table>
Outcomes

- Engineering design
- Mathematical thinking and predictive analysis
- Coding
- Abstraction
- Gender role shift
Engineering design

- Identifying the problem, recognize constraints, collect initial data for robot performance, develop solution, program robot
- Test and retest as needed to produce final solution
- Present solution to teacher and peers
Mathematical thinking

• Students analyze initial robot movement and predict coding needed to obtain desired performance
• Learn to relate quantitative data to control of motors
• “So a time of .4 was too much, .3 too little …”
• “34 hundredths then? 35?”
Coding
Abstraction

• Early in the process – one move of robot programmed and then tested
• Later in the process – multiple moves programmed at once and program “read” to determine how the robot would behave
• Students learned to judge how robot would behave based on abstract symbolism of Rogic code
Gender role shift

• In one of the mixed gender teams
  • Initially the boy gave directions and the girl keyed the program
  • Later the girl challenged the boy to explain directions and challenged him with an alternative solution

• Survey also gave evidence of shift in girls’ confidence
Additional unit being developed

- Target audience is grade four
- Key theme is universal systems model
- Context is communication using light – *Optical Odyssey*
Dissemination

http://robotics.coe.uga.edu/
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