TEACHING EVOLUTION TO NON-ENGLISH PROFICIENT STUDENTS BY USING LEGO ROBOTICS

AUTHOR

L. Elena Whittier is an ESL Teacher at Proctor R. Hug High School in Reno Nevada.

Michael Robinson is Professor of Secondary Science Education at the University of Nevada, in Reno, Nevada.

ABSTRACT

This article describes a teaching unit that used Lego Robotics to address state science standards for teaching basic principles of evolution in two middle school life science classes. All but two of 29 students in these classes were native Spanish speakers from Mexico. Both classes were taught using Sheltered Instruction Observation Protocol (SIOP). The evolutionary robots (Evobots) unit was comprised of twelve 60 minute classes. The students worked in cooperative groups to build and test Evobots that could either be the best at one thing (a specialist) or second best at everything (a generalist). After building the Evobots, the teams of students competed in four events: climbing, hauling, speed, and strength. Students then compared the different bots and proposed ideas explaining why each bot either won or lost the various competitions. Students used this information to write final papers summarizing the unit and their knowledge of concepts such as natural selection, adaptation, and niche specialization. Average knowledge gains were sizeable with the mean scores of the pretest and posttest of 26.9% and 42.3%.

INTRODUCTION

The place of evolution in standard science curriculum is becoming ever more precarious as various religious groups seek to supplant the theory of evolution with the idea of “Intelligent Design.” As these groups gain polit-


ical ground, the urgency for finding innovative and powerful methods of teaching known evolutionary facts, such as natural selection, is increasing. In order to meet mandated science standards, comply with the guidelines of the NCLB Act, and build the factual framework surrounding the natural world, science teachers must continue to present the theory of evolution and its many components to their students. Using ideas from various middle school teachers, help from university students and professors, and personal ingenuity, the Evobots Unit was born out of Lego robotics and Robolab (Cyr, 2002; Wang 2002) to accomplish just that.

The nature of science lends itself to group-based concrete activities that offer students the opportunity to not only learn English vocabulary, but also to gain a better grasp of science concepts when they are associated with inquiry and hands on learning. This paper describes how robotics was used to address the evolution part of the life science content standards for Non-English Proficient (NEP) classes in a Western state. The connection of robotics to life science content and pedagogy, as well as engineering principles and design, is also addressed. The curriculum discussed in the paper also addresses the need for both different teaching strategies and curricula for NEP students in science classes. This is undoubtedly needed if the science achievement of these students is to improve. More importantly, it is needed if they are to learn and be able to use the everyday English and science vocabulary that is needed for science and technology literacy in a modern technology-based society.

**BACKGROUND**

Research on the use of science to develop language acquisition is not widespread but it indicates that concrete materials (science materials and equipment) and student group work in science lab activities, can accelerate second language acquisition (Case, 2002; Gibbons, 2003, Robinson, 2005). Gibbons research with fifth grade science students, comprised of over 90% speakers of English as a Second Language (ESL), indicated that the use of science materials (magnets and associated materials) and group work, led to the use of more spoken English and the learning of associated science terminology.

Experienced science teachers would generally expect that the materials and social interaction of hands on science should lead students to see the science as more interesting and relevant. Research by Robinson (2005) regarding teaching middle school physical science to ESL students and regular classes with high percentages of NEP students indicated the following: 1. Working with the robotics materials helped students practice
problem solving and inquiry skills. 2. The National Science Education Standards (NSES) goal of promoting inquiry (NRC, 1996) was addressed in the small group work with the robotics materials. 3. Small group work with Lego robotics materials helped make the physical science content more relevant and interesting to learn. 4. Teaching strategies that use visuals and concrete materials, e.g. Lego Robotics, helped NEP and ESL students develop vocabulary faster. Research by other educators also supports the value of peer-peer or social interaction between students for joint construction of knowledge (Donata, 1994, Ohta, 1995, Vygotsky, 1981).

**EVOBOTS: THE BEGINNING**

The saying, “Fine minds think alike,” truly applies to the evolutionary robots (Evobots) Unit. Although the name of the unit and idea for the Power Point presentation (though not the presentation itself) originated with another middle school science teacher in the school district, the idea behind the unit came to one of the authors separately and equally. The basic concept was simple, use the Lego Robotics tools to teach evolution. More specifically, the unit was designed to convey evolution related state science standards for middle school:

1. Common ancestry (Standard 9.8.1)
2. Natural selection (9.8.2)
3. Adaptation (9.8.3)
4. Evidence of evolution (9.8.4)
5. Extinction (9.8.5)
6. Niche Specialization (15.8.2)

Each concept was addressed four ways: building with the Legos, discussion (group and class), supplemental reading from texts, and written responses.

**METHODOLOGY**

**SUBJECTS**

The students in this study were from an at-risk, low socioeconomic, Title I school with 800 students in grades seven and eight. Of the 29 students in the study, 16 were in seventh grade and 13 in eighth. All participating students belonged to the Non-English Proficient (NEP) language group, having been in the United States for two years or less. Most were native Spanish speakers from Mexico, but two spoke Tagalog, the national language of the Philippines. The classes were two sheltered life science
courses that met every other day and consisted of only seventh or only eighth graders. Both classes were taught using parts of the Sheltered Instruction Observation Protocol (SIOP) designed by Echevarria, Vogt, and Short (2004).

**Pre Assessment**

Before Evobots began, students were given a pretest on Change Through Time, Chapter 19, from *Concepts and Challenges in Life Science* (Wolfe, Berstein, Schachter, & Winkler, 1998), the text of record for this unit. They were also asked if they knew the difference between a specialist and generalist, the answer to which they did not know. Though their academic backgrounds before coming to the United States differed greatly, the pre assessment showed that the students had minimal knowledge of evolution or related concepts whether it was in English, Spanish or Tagalog. This unit was the first time any of the students had actually formally studied evolution.

**The Evobots Unit**

The Evobots unit was comprised of ten 60 minutes classes from start to finish (Appendix). A supplemental fossil activity lasting two days was added after the posttest, but it could be left off if time were an issue. Before anything was said or done, the students were given the aforementioned pretest. After the pretest, the unit officially began with a Power Point presentation about specialists and generalists. Using pictures of modern cars and representative animals as examples, the presentation focused on four categories of specialists: those with climbing ability, hauling ability, strength, or speed. The end of the presentation showed various generalist animals and cars.

After the presentation, students were shown a base model Lego Robot (the primitive Evobot) and given an oral description of the goals of the unit. They were told that they were being tasked to build an Evobot that could either be the best at one thing (a specialist) or second place at everything (a generalist). While they could add to or change certain features of their bots, such as tires and gears, they could not manipulate the basic structure of the Legos or add extra motors. Students then formed groups of four and chose the strategy they preferred: specialist (specifying which type) or generalist. A written description of their chosen strategy as well as a rough sketch of the Evobot was turned in at the end of the period.

The next few days were spent building and testing the Evobots. Students were asked to research features of specialist or generalist animals
that would help improve their Bot's chances of success in their chosen competition(s). Each student was also given a cooperative role in the group to ensure equal participation and individual accountability of group members. Supplemental readings and homework from the text were also assigned to enhance students' knowledge of the concepts being learned in the Evobots unit. Cooperative learning strategies helped facilitate text selections and provided students with verbal and aural English practice. Homework came directly from the readings and was completed both in and out of class. Since the classes met only every other day, the twelve-day unit actually took about a month to complete. Upon arrival of the real Evobots competitions, each group tested their Bot in each event.

The Competition

In the climbing competition, Evobots started on a level, carpeted surface, approximately two inches from an inclined board. The Bot had to drive up the incline to a marked “Finish Line” near the end of the board. If the Bot reached the finish line, it could continue to the next round. If it did not reach the finish line, the team was given one more attempt before being eliminated from that competition. The incline started with three encyclopedias (about four inches) under one end of a board and was raised by one encyclopedia until only one Bot remained in the competition. The remaining Bot was the winner.

In the Hauling Event, Evobots were given various plastic weights to carry. If the weights fell off during the first run, the Bot was given one more opportunity to carry the weights. The Bot that could carry the most weights without letting them fall off was the winner.

The Speed Competition was a typical race situation. The Bot with the fastest time from start to finish was the winner. Each Bot was given two opportunities to race individually.

In the Strength Competition, each Bot started on the edge of a “Sumo circle.” The last Bot knocked out of the circle was declared the strongest. This competition proved too difficult for the simple programmed Evobots to do, so the result was no winners in this event.

The final part of the unit consisted of a posttest and a written summary of the Evobots unit. Throughout the unit, however, discussions were held each class period about how the various structural changes to the bots could be analogous to the natural world. Discussions also followed the text readings and focused on topics relevant to the science standards. One class period focused almost exclusively on the fossil record of horses and humans and how it related to evolution and was
Teaching Evolution to Non-English Proficient Students by Using LEGO Robotics

Whittier/Robinson

analogous to the student designed bots. After the competitions, students compared the different bots and proposed ideas explaining why each Bot either won or lost the various competitions based on its structure. Students then used this information to help them write their final papers summarizing the unit.

RESULTS

As expected, nearly all students showed significant gains in their individual conceptual understanding of evolution based on pre- and posttest scores (Figure 1). The mean score on the pretest was 26.9% while posttest scores averaged 42.3%. Three students missed either the pretest or posttest. The average percent gain for students in this unit was 15.4%.

Teacher assessments of writings from Evobots Parts One, Two, and Final also improved from the beginning of the unit, where Evobots Part One averaged 2.1 (out of four). The final papers had an average score of 3.0 (out of four).

Though students did not master the concepts presented, they did make notable gains in knowledge of evolutionary topics. More importantly, beyond the tests, students were able to both discuss and write about topics integral to a strong science foundation. Regular discussions of natural selection, adaptation, and niche specialization became commonplace among the students in these classes. Relevant vocabulary was not only explicitly discussed and emphasized, but also studied through contextual clues. New terms were integrated into teacher language and class discussions each period. For beginning level English Language Learners (ELLs) such conversations are no small feat considering the extensive vocabulary involved.

![Figure 1. Students Pre- and Posttest Scores for the Evolution Unit](image-url)
DISCUSSION AND CONCLUSIONS

The Evobots unit proved hugely successful for the ELLs in these classes. Given the amount of time in the country and the English language abilities of many of them, completing this unit in its entirety provided students with a serious background in evolution. The use of hands on devices, such as the Lego Robots, allowed all students to experience firsthand the process organisms undergo in nature. Coupling this with readings and discussions really drove the point home that evolution is real and we can see its processes and effects even today. Moreover, students had the opportunity to use advanced technological components to discover the process of niche specialization.

The personal evaluation of the classroom teacher author is that using the Evobots can give the teacher a way to show students a process that is otherwise very slow and difficult to observe. Students may be aware of bacteria and insects becoming resistant to antibiotics or insecticides, but they may not connect it to evolution since it is so abstract. But, the power of witnessing “evolution” in the classroom left no room for argument among students about the validity of this theory. In fact, for the first time in the teacher author’s career as a science teacher, the controversy surrounding evolution never arose. Even when how organisms change over time was discussed and the existence of a common ancestor, students dove into the conversation and presented a variety of scientifically based viewpoints. It appeared that the demonstration provided by the Power Point presentation, student research on various specialists, and then the building and revising of the Evobots helped students understand that, while the origin of life may be up for discussion, evolution itself is an indisputable fact.

Furthermore, the Evobots enabled students to learn a lot about simple machines, friction and engineering design. Science processes, problem solving and inquiry, and general, engineering design were a major part of the construction, testing, and redesign of the bots and these skills should have transfer to future science courses and problem solving in everyday life. The team discussions and problem solving also provided a good vehicle for practicing the new science words and everyday language of English.

SUGGESTED CHANGES

When this unit is used in the future, the teacher author would like to make the following changes. First, an additional pretest that has students evaluate their attitudes about technology and robotics, though not specifically engineering, will be used, since this unit doesn’t address that.
Second, another competition to test strength will be developed, since the Sumo circle did not work. Third, separate programs in Robolab that can be used for each of the specialist challenges will be developed. Fourth, more research time will be incorporated through going to the library and allowing students one or two days to really become familiar with their specialist or generalist of choice. Fifth, the unit will be revised to encompass the eight SIOP components in their entirety so that any teacher with the Lego equipment may use the unit. Finally, all of the Evobot packets will be assembled ahead of time so the students can receive them at the beginning of the unit. All in all, however, even the first, unrefined version of this unit demonstrated that it could provide Non-English Proficient students with success in learning grade level science standards and having many opportunities to use their new vocabulary during the construction and testing of the bots.

REFERENCES


## APPENDIX

### Evobots Unit Plan

<table>
<thead>
<tr>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
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| • Ch. 19 Pretest  
• Power Point  
• Explain project  
• Form teams  
• Practice building on base model  
• Groups write up strategies (specialist or generalist)  
• Class discussion of daily concepts and challenges | • Complete “Evobots Part One” (handout, Appendix B)  
• Class discussion of daily concepts and challenges | • Test bots in mock competition  
• Revise plans/bots  
• Complete “Evobots Part Two” (handout, Appendix C)  
• Class discussion of daily concepts and challenges |

**Content Objectives:**  
You will be able to choose a plan for your Evobot: speed, strength, climbing, hauling, or generalist.

**Language Objectives:**  
You will be able to write a rough draft of your Evobot plan.

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<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
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| • Finish Bot revisions  
• Begin Ch. 19 supplemental packet  
• Rally Robin reading of 19-1 “How are fossils formed?” and 19-2 “What is geologic time?”  
• Do corresponding packet pages with partners  
• Class discussion of daily concepts and challenges | • Begin real competitions: Climbers & Haulers  
• Jigsaw reading of 19-3 “What is evolution?” and 19-4 “What is natural selection?”  
• Do corresponding packet pages in groups after Jigsaw  
• Class discussion of daily concepts and challenges | • Finish Evobots competitions: Speed & Strength  
• Jigsaw reading of 19-5 “What evidence supports evolution?” and 19-6 “How have humans changed through time?”  
• Discussion of readings  
HW: Packet pgs. 19-5, 19-6 |

**Content Objectives:**  
You will be able to test the abilities of your Evobot at the different challenges.  
1) You will be able to test the abilities of your Evobot at the different challenges.  
2) You will be able to read and discuss different features of evolution.

**Content Objectives:**  
You will be able to use your Evobot to compete against others and prove that yours is the most fit.

**Content Objectives:**  
You will be able to use your Evobot to compete against others and prove that yours is the most fit.
### Language Objectives:
You will be able to talk about what features of your Bot are successful and which ones are not.

### Language Objectives:
You will be able to discuss the factors that cause change and select organisms to live or die.

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You will be able to discuss the factors that cause change and select organisms to live or die.

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<tr>
<th>Day 7</th>
<th>Day 8</th>
<th>Day 9</th>
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<tr>
<td>• Complete Ch. 19 packets with group &amp; teacher help&lt;br&gt;• Class discussion of daily concepts and challenges</td>
<td>• Discussion of fossil record of horses &amp; humans&lt;br&gt;• Review Ch. 19</td>
<td>• Writing: &quot;Evobots Final&quot; (handout, Appendix D)&lt;br&gt;• Continue Ch. 19 review&lt;br&gt;• Class discussion of daily concepts and challenges</td>
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### Content Objectives:
You will be able to review the main concepts of evolution.

### Content Objectives:
You will be able to understand the importance of fossils in the theory of evolution.

### Content Objectives:
You will be able to evaluate the success (or lack of success) of your Evobot.

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<th>Day 10</th>
<th>Day 11</th>
<th>Day 12</th>
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<tr>
<td>• Ch. 19 Posttest</td>
<td>• Making fossils activity (text p. 383, Appendix E)</td>
<td>• Take out fossils&lt;br&gt;• Write a story about your fossil addressing: what, how, why, where, when, who (transparency, Appendix F)</td>
</tr>
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### Content Objectives:
You will be able to demonstrate an understanding of the basic concepts of evolution.

### Content Objectives:
You will be able to create your own fossil.

### Content Objectives:
You will be able to invent and discuss (with a partner) a story about your fossil from your imagination.

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<tr>
<th>Language Objectives: You will be able to read your science text for answers to questions about evolution.</th>
<th>Language Objectives: You will be able to read and discuss other important factors of evolution.</th>
<th>Language Objectives: You will be able to write about factors that may have influenced your Bot and reasons for their influence.</th>
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<tr>
<td>Language Objectives: You will be able to correctly write answers to questions about evolution.</td>
<td>Language Objectives: You will be able to read and follow directions in English for making a fossil.</td>
<td>Language Objectives: You will be able to write a story about your fossil answering such questions as: who, what, when, why, where, and how.</td>
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**28**