# 2007 AAAS/Subaru Essay Writing Competition for K-12 Educators, Finalist Essay

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## Forest Ecology: From Baseball to Acid Rain

### Introduction

The eighth-grade students were very excited. Finally they were taking an active part in an international learning community. Our middle school was involved in a collaborative science project with our sister high school from Israel, which culminated in the visit of the Israeli students and the presentation of the collaborative research to the community.

As a scientist and a researcher that became involved in curriculum writing and science and math education, I had a vision of how science and math education in the 21st century should look. There are numerous guidelines that must be included in such science and math educational programs:

1. Science should be taught as a multidisciplinary concept that is often integrated with math.
2. The emphasis should be on providing the students with thinking and inquiry tools rather than pure knowledge.
3. Scientists and researchers from academia and industry should be involved in the program. This involvement is crucial in presenting the students with up-to-date science and introducing the students to "real life" science.
4. Modern technological tools should be incorporated into the classroom and the science lab to enhance learning opportunities.
5. The importance of collaboration in scientific research should be introduced and emphasized to the students. This can be achieved by creating learning communities inside school, inside the immediate community, or internationally.

This essay discusses one project from the New Science and Math Initiative that I have established and demonstrates how the guidelines stated above were embedded into this project.

### Forest Ecology

This project took place in a private school in Stoughton, Massachusetts, but was recently presented as a model for community and differential learning to other day schools. It was a part of a broader science/math program that aimed at providing students with cutting-edge science and math education with the hope of creating curious students who will grow into budding scientists. The project included many hands-on activities and favored collaborative learning in small groups as well as mini-research projects.

The title of the project was "Forest Ecology: Comparison of the Mediterranean and New England Pine and Oak Ecosystems" and its goals were:

- To understand basic definitions and concepts in ecology. These definitions served as the foundation to research our nearby ecosystems and compare them to the Mediterranean ones.

- To define the biotic and abiotic parameters in each ecosystem and get acquainted with oak and pine trees (macro- and microscopically).
- To conduct research on these systems (including determining a research topic, formulating a hypothesis, conducting the research, and analyzing the data).

**Guideline 1: Multidisciplinary hands-on science that encourages inquiry thinking**

The first and the most important concept in ecology is that of a **system.** To teach the meaning of this concept, the students were divided into groups rotating between a few stations. Each station had a different object and a questioner—a Monopoly game, a toy fire truck, a picture of the human body, and a poster of a rain forest with its various habitants. At the end of the class, the students were able to independently conclude that:

1. A system is made of parts with specific rules of interactions amongst them.
2. There are three types of simple systems—static, working (requires energy), and living.
3. Living systems need to follow certain requirements (ability to multiply, self sustained, metabolic activity, etc.). This conclusion opened the door to the discussion, "Are viruses living systems?"
4. The human body is a complex living system which is comprised of several simple systems (cells, tissues, organs).
5. An ecosystem is a complex system, composed of more simple systems. Some of them are living (biotic) and some non-living (abiotic).

Conclusions 3, 4, and 5 were based on and integrated in the students' previous knowledge in life science, ecology, cell biology, the human body, and biochemistry.

**Integration of science and math:** In order to teach the students about the energy pyramid, the "survival game" was played in the school yard. The students were divided into groups of Herbivores, Omnivores, and Carnivores. We had a few starting rules for predation. Every ten minutes, the students had to pause, count the survivors, and decide whether the rules of the game, and hence the numbers of animals that survived in each group, agreed with the energy pyramid that they studied.

After a few cycles, the students came up with their own ideas on how to model the pyramid and modify the game's rules. This was a lesson in integrating math and ecology and in independently identifying the notion of good scientific modeling.

**Guideline 2: Encouraging inquiry and scientific thinking**

To better clarify the basic concepts in ecology and to look more carefully into an ecosystem, the students, working in pairs, built a mini lake ecosystem with components that were brought from our local lake. After observing and documenting their ecosystem for two days, the students were asked to design an experiment which would demonstrate that a system is built from interacting parts, and therefore, when one part is either taken away or changed, the balance is tipped.

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Since the students were not used to designing their own lab or coming up with their own hypothesis, the process was very slow. These steps were the most difficult:

1. Jumping from the big question into a small, well-defined hypothesis.
2. Designing a means to test the hypothesis.
3. Understanding that each experimental system should have a control and experiment in it that will be compared to each other.
4. Understanding that only one(!!!) variable can be changed in each experiment.
5. Understanding that "adding sugar" or "pouring vinegar" is not a mean, but rather, a tool and the condition that will be changed by the tool is "the osmotic pressure" or "the acidity or pH" of the system.

All students mastered these five concepts after about a week of designing and executing the experiment. The students now design their own experiments in the science lab.

**Differential evaluation:** The class assignment described below aimed at testing the students on the ecological concepts they studied. The students had to research and document an existing ecosystem using as many definitions as they could from an ecological dictionary we created.

Students with special needs were given the option to either create a system (one student created her own island) or to look at systems with which they were familiar and describe them. The assignment was put together in a PowerPoint format and presented to the class (which helped me in providing the students with tools to create good and effective presentations and modes to orally present them). Here are two examples for creative ecosystems that were created and presented by special needs students:

1. The Red Sox baseball team and Fenway Park: This presentation was created by a partially deaf, slow-learner student, who loves baseball. His outstanding knowledge of baseball in general, and more specifically of his favorite team, helped him to cover all the parts of the system (biotic and abiotic) and the way they interact.
2. My household: This was a humoristic presentation that looked in detail at the interactions of the household members (including predation and parasitism) and named "the birth of my baby sister" as a natural disaster. The presentation was created by a student who has many difficulties in writing. Therefore, the animation and his actual presentation exceeded the quality of the written parts.

**Guideline 3: Active involvement of the scientific community**

There were three academic resources that accompanied our project. The first was the Mass Audubon Society that offered us an introductory hands-on unit at their Moose Hill ground covering the Pine and Oak ecosystems. The second was "Simbiotic"—a MIT-based software company that offered us the use of new educational ecology software which was not yet commercially available. The third one was a reference center at the Technion's EcoPark (Haifa, Israel) where students (from our sister school) could visit and collect their data and faculty members were willing to answer (by e-mails) questions from Boston and Haifa students.

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**Guideline 4&5: Technological tools and collaborative learning**

A central theme in a successful, modern science project is collaboration, most often one that crosses boarders and oceans. This collaboration was supported by modern technology (including electronic mail, video conferencing, imaging, etc.). The main theme for our forest ecology project was a trans-Atlantic collaboration. The students were divided into ten teams. Each team included ten USA and three Israeli students. The research topics were decided and discussed collaboratively and the data was collected and transmitted amongst the teams' members and their mentor on a weekly base. Our school received a grant for video conferencing equipment and we have added the "Skype" software to all our laptops. In addition, the students were required to communicate by e-mail at least once a week. Similar communication also occurred between our students and Technion's faculty members from Israel, who agreed to help us in the project.

*"It is the tension between creativity and skepticism that has produced the stunning and unexpected findings of science (Carl Sagan)."* Whether through forest ecology, or other projects, I am hoping that this tension was sensed by my students, inspiring them to become budding scientists.