Looking for a way to help your students become technologically savvy, communicate in a meaningful way about their classroom science explorations, and interact with working scientists? A Web-based Integrated Science Environment (WISE) project may be for you.

WISE is a free, online science-learning environment (wise.berkeley.edu) for students in grades 4–12 and supported by the National Science Foundation. The website was developed at the University of California at Berkeley six years ago.

Curricular units within this learning environment—such as the "Plants in Space" project discussed in this article—were created by multidisciplinary partnerships of teachers, university professors, scientists, researchers, and technology specialists from various institutions who shared the goal of wanting to find a way for students to explore contemporary scientific issues through designing, debating, and critiquing solutions on the World Wide Web.

We were part of the team of educators that developed the Plants in Space curriculum and would like to share our observations of a fifth-grade class as they completed this exciting WISE project.

Connecting to WISE

When teachers register on the WISE website, they gain access to more than 30 inquiry projects to do with students. The WISE project library provides information to help teachers select a project appropriate to their curriculum—topics include plants, earthquakes, water quality, heat and temperature, rainforest interactions, life on Mars, and light. Other online resources include lesson plans, suggestions for discussions, additional activities, assessments, and lists of standards addressed by the projects.

Once a project is selected, students pair up to conduct investigations in class and via the Web and communicate directly with scientists about their investigation experiences. In return, the scientists provide the students and teachers with feedback, ideas for further study, and much more.

To implement a WISE project in your classroom, all you need are computers and an Internet connection. We recommend Power Macintoshes, running Mac OS 8.0 or later, or Pentium PCs, running Windows 95 or later. Each computer must have an Internet browser such as Netscape Navigator 4.08 or higher or Microsoft Internet Explorer 4.5 or higher. Online resources are provided to assist new users in preparing to run a WISE project.

The Challenge

In the fifth-grade classroom we observed, the teacher introduced the Plants in Space project by explaining to students they would spend the next five weeks helping scientists determine which plants—regular...
Identify factors affecting plant growth
Pairs of students make online predictions about what plants need to live and discuss them with classmates. Using the Internet, students explore sustaining plant life on Earth and in space. Students take online evidence notes, participate in small- and whole-group Web discussions, and seek guidance from scientists online when needed.

Discuss plant needs with scientists
Students discuss plant needs with scientist partners in online discussions. They assess the challenges of growing plants in space and other extreme situations, such as a desert environment.

Grow plants under varied conditions
Students compare a hydroponic and soil garden, contrasting three different durations of light per day (0, 12, and 24 hours) with two types of plants (radishes and “AstroPlants”—a type of Wisconsin Fast Plant™).

Record and interpret data
Students compare plants by observing the height and stage in the life cycle. They record features such as height, number of leaves, number of flowers, etc. They learn that radishes grow taller and go through their life cycle slower than AstroPlants; they observe that 24 hours of light results in optimal plant growth.

Analyze results
Students pool their data and discuss plant life cycles and plant height. They consider which features are best for growing plants in space.

Figure 1.
Plants in Space project activities.

Figure 2.
A screen shot from a WISE investigation.

In the online investigations, students would investigate the factors needed to sustain plant life on Earth and explore different conditions for growing plants in space. In the classroom investigation, students would grow both types of plants under various conditions. Throughout both phases of investigations, students would communicate with scientists online, who would guide them as needed in their studies.

This project met fifth-grade content and inquiry standards (see Connecting to the Standards on page 35) while promoting technology and literacy. Figure 1 summarizes how the project fit into the curriculum and involved both hands-on explorations and use of the Web.

Online Investigations
For the first two weeks of the study, students immersed themselves in the interactive online environment. Students predicted what plants might need in order to live on Earth and discussed their predictions and the reasons behind them both online and with classmates.

They also completed several online investigations, reading and critiquing information on the site about the role of water, nutrients, light, and air in sustaining plant life on Earth. For example, while investigating the role of light in photosynthesis, students took evidence notes, participated in small- and whole-group...
Online discussion question:
“Can plants where you live grow in the desert? Why or Why not?”

Shelly/Mia: “We don’t think plants that live in our environment can grow in the desert. We know that most plants living around us need water almost every day. Therefore, most plants around us can’t live in the desert because the desert does not get enough rain. What other plants besides a cactus can grow in the desert?”

Scientist D: “I’ve seen some scrubby trees growing in the desert, up on the rocky hillsides. I wonder what allows some plants to grow in the desert and not others?”

Thomas/Michael: “Some plants can grow in the desert because they have water inside of them.”

Shelly/Mia: “We think we know the answer to your question. We think that some plants are used to hot air and some are used to more cold air than hot air.”

Erika/Mary: “Some plants CAN grow in the desert, such as grass. The reason we think grass can grow in the desert is because grass makes its own moisture. That means it can survive in the desert and won’t become dehydrated.”

Scientist T: “Most plants that live in temperate climates (like most of the United States where they have four “normal” seasons) cannot tolerate long periods without water. Desert plants can tolerate long dry periods because of a number of adaptations. Many have a thick, waxy skin to prevent drying out and can store water for long periods. Desert plants have small pores called stomates that they can open or close to breathe. Many desert plants keep their stomates closed during the day and breathe in carbon dioxide at night when it is cooler and not so dry. Other desert plants have very deep root systems to find any water that is available. Others flower and produce seed in a very short period of time to take advantage of short wet seasons. So, desert plants have adapted over many years to their particular environment. Other examples of desert plants are sages, rice grass, horsebrush, pickleweed, and juniper. These are all small brush or bushlike plants that have adapted to dry climates.”

Growing Plants
Over the next three weeks, during the second phase of the study, students continued their online investigations—this time learning about the conditions necessary to grow plants in space. In these online investigations, students reviewed information about the conditions necessary for growing plants in space (i.e., the amount of space for growing plants in a shuttle, the types of lighting sources used on NASA shuttles) and discussed, both online and in class, how those conditions determine which plants are more feasible to grow in a space-shuttle environment.

Meanwhile, students also began growing plants in the classroom. Students were given two groups of seeds, “A” and “B.” Students knew that the seeds were either Earth plants (radishes) or AstroPlants (the Wisconsin Fast Plant™, Brassica rapa, a member of the broccoli family bred to have a short life cycle). The teacher discussed the life cycles of Earth plants and AstroPlants and challenged students to figure out which of the growing plants were AstroPlants.
Figure 3. An excerpt from a conversation between students and scientists.

At the end of the investigation, students pooled their data and discussed plant life cycles and plant height as they considered which features are best for growing plants in space. From their classroom growing experience, students had observed that Earth plants (radishes) grow taller and go through their life cycle slower.

Figure 4.

Pre- and posttest responses from two students to the question, “If astronauts want fresh vegetables in space, could they grow plants inside a space shuttle?”

<table>
<thead>
<tr>
<th>Student</th>
<th>Response</th>
<th>KI Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erika (pretest)</td>
<td>“No. I chose my answer because when the astronauts tried planting the pot with vegetables would bounce off. Which would cause the plant to destroy.”</td>
<td>2</td>
</tr>
<tr>
<td>Erika (posttest)</td>
<td>“Yes. The reason I chose this answer is because astronauts are able to grow any plant on a space shuttle if they prepare it before. When you make a plant on a space shuttle you have to consider the space. Also, you have to think about the light source like LED’s lighting. The nutrients plants need could be artificial. You need something to clean the hydroponic container with which contains water.”</td>
<td>5</td>
</tr>
<tr>
<td>Jason (pretest)</td>
<td>“No. I picked no because if there is no gravity, then the water will probably fall to the floor. [Since] you need water to grow, the water will probably fall to the floor before it gets into plant holder because there is no gravity.”</td>
<td>1</td>
</tr>
<tr>
<td>Jason (posttest)</td>
<td>“Yes. The main reason for my answer is because I’ve seen an actual plant chamber. I also know because I grew Astroplants that you can grow in space. There needs to be a box so won’t fall over, a fan for air, and lights for the sun.”</td>
<td>4</td>
</tr>
</tbody>
</table>

Figure 5. Knowledge integration scoring guide.

- 0 No answer or do not know or repeated question
- 1 Reasons are confusing or not normative, explanation(s) are beyond what the question is asking
- 2 Mixed Transfer: meaning normative answer in a sense, but explanations are beyond what question is asking for or a normative answer is provided, but no explanations and details are provided
- 3 Normative answer with one explanation
- 4 Normative answer with two explanations
- 5 Normative answer with three or more coherent explanations

For the investigation, students set up hydroponic (grown in a nutrient medium instead of in soil) gardens under three different lighting conditions (0, 12, and 24 hours). Every student pair planted both types of seeds in a 12-hour lighting environment; then one-half of the pairs planted a second set of seeds under 24 hours of light, while the other half planted a second set of seeds in a no-light environment. Students observed the plants’ development daily, recording features such as height, number of leaves, and number of flowers.

Analyzing and Sharing Results
Throughout the investigation, students discussed the progress of their plant studies with their peers and asked the online scientists to help when they had questions. The conversations ranged from direct questions to scientists to students’ thoughts on the challenges of growing plants in space and other extreme situations, such as a desert environment. Not only did scientists provide answers to students’ questions, they also helped students to construct a feasible solution through questioning students. Figure 3 (page 33) shows an excerpt from a conversation between students and scientists.

At the end of the investigation, students pooled their data and discussed plant life cycles and plant height as they considered which features are best for growing plants in space. From their classroom growing experience, students had observed that Earth plants (radishes) grow taller and go through their life cycle slower.

By using the Web to ask scientists questions, students improved both their ability to communicate about science and their fluency with information technology.
than AstroPlants; they also observed that 24 hours of light results in optimal plant growth.

From their conversations with scientists, students had learned why space-shuttle travelers prefer to grow plants in 24 hours of light (to speed up production of fresh vegetables and oxygen) and had discussed the importance of research on plant life in a zero-gravity environment.

Through these online and classroom investigation experiences, by the end of the project, most students understood how plants could survive in extreme conditions, such as in a space shuttle. Students could interpret their investigations of plant-growth conditions and recommend ideal light levels for plant growth. They could also distinguish between plant height and plant maturity based on the time required to complete the life cycle.

### Assessing Student Learning

To assess student learning, identical essay tests were administered before and after completing the Plants in Space project. For example, one test question asked, “If astronauts want fresh vegetables in space, could they grow plants inside a space shuttle?” Figure 4 contains pre- and posttest responses from two students. Each question was coded using a 0–5 knowledge integration (KI) scale that evaluated quality of the student’s responses (see Figure 5).

These answers provided the teacher with a window into the thinking of students about the science content. The teacher used the test results to assess the progress of the entire class and to identify areas in need of improvement.

### WISE Benefits

Participating in the WISE project helped students learn, in a guided way, how to plan research, record data, analyze results, and extrapolate from the results. By using the Web to ask scientists pertinent questions—such as, “How do I figure out which plant completes the life cycle faster?”, “Why would you want the plant to have a fast life cycle?”, and “Why might plants that grow in 24 hours of light help scientists on a space shuttle?”—students improved both their ability to communicate about science and their fluency with information technology.

The interactive nature of the Web and the access to real scientists through the WISE website was another factor in the project’s success. The teacher now uses WISE technology in science every year because it allows “students to create their own knowledge by generating questions, exposing problems, and searching for answers and solutions.”

In addition, the interaction with working scientists helped students better appreciate the role of science in their lives. Reflecting on the Plants in Space project experience, most fifth-grade students disagreed with the statement: “The science I learn in school has little or nothing in common with my life outside of school.” As one student elaborated, “I disagree because when you walk that’s a part of science. When I grow plants at home like roses, radishes, sunflowers, and daffodils that’s a BIG part of science.”

Hearing student comments like these, we’re proud to be among those who have gotten “WISE” to the benefits of programs that foster inquiry learning and technology skills.

**Connecting to the Standards**

This article relates to the following *National Science Education Standards* (NRC 1996):

#### Content Standards

**Grades 5–8**

**Standard A: Science as Inquiry**

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

**Standard C: Life Science**

- Populations and ecosystems

**Resources**


**Internet Resources**

Fast Plants

[www.fastplants.org/home_flash.asp](http://www.fastplants.org/home_flash.asp)

WISE: The Web-based Integrated Science Environment

[wise.berkeley.edu](http://wise.berkeley.edu)