

# The Never-Ending Story



## Questioning Strategies for the Information Age

*By Cathleen Galus*

**Subject:** Project-Based Learning, Information Literacy, Neuroscience

**Grade Level:** K-12 (Ages 5-18)

**Technology:** MicroWorlds (LCSI), Cocoa (created by Apple, now licensed by Stagecast); e-mail; Internet connection

The project-based learning environment may well be the classroom of the 21st century. It may come to be simply because technology allows a teacher to direct students through experiences that bring understanding of the material they study. The author of this feature article shows how educators can engage children in this new way.

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At the end of the day, don't ask students what they learned, ask them whether they raised a good question. A good question leads to more new questions, new discoveries, new realms never even considered before. These questions lead to deeper understandings of the world that the questioner wants to know. Teachers should share the excitement of asking questions and finding answers to personally relevant questions.

In student-centered inquiry classrooms, teachers motivate children to explore and "facilitate" or "scaffold" their understandings of the world. In this type of learning environment, the teacher provides children with resources and activities that help them create and develop their ideas. This constructivist model provides a structure for inquiry about the world, testing, research, and reflection on ideas. In my fourth- and fifth-grade science classroom, this includes a "learning on demand" element. We address both the children's and the teacher's curricula. This is the antithesis of the traditional classroom in which the teacher is the sole deliverer of knowledge and has a predetermined curriculum outlined for "coverage." In the traditional model, the student is a recipient of knowledge. Learning on demand, on the other hand, respects the interests of children in curriculum design and the learning process.

The teacher still provides rich science resources, whether discussions, lessons, dissections, hands-on experiences, field trips, demonstrations, or contact with experts in person, by e-mail or Internet, and by guest lecture. But it is the element of scientific inquiry that comes prominently into play. Students begin a new area of study by brainstorming "wonder" questions, developing driving questions, and devising their own hypoth-

eses and experiments in a student-centered room design.

Eight science process skills—observing, communicating, comparing, ordering, categorizing, relating, inferring, and applying—are presented by the teacher when they can best be used to find out information about the world. They are then discussed and used in appropriate ways.

Students use computers and MicroWorlds Logo to create science simulations that *show* rather than tell their understandings of science. Students brainstorm and learn the differences between animation (i.e., movement to show how something works) and simulation (i.e., an environment in which variables can be changed by the user to change an outcome). Throughout the project, students create a simulation design in collaborative groups. The groups provide a forum for students to reflect on their own and their peers' science understandings, and the students use their peers as resources to further their own understandings.

The teacher in this environment is the facilitator. As such, he or she models inquiry and questioning, creates a student-centered and -directed learning environment, and provides lessons, learning resources, guidance, and scaffolding in response to research questions that student teams wish to pursue. Students develop and pursue personally

meaningful research questions both individually and collaboratively. Through the questioning strategies and classroom activities, the teacher can help students evolve through asking and developing driving questions and acquiring information-literacy skills while advancing their science understandings.

### Strategic Steps

The first step is to *engage* students in asking questions. At the beginning of a study, elicit wonder questions about the topic. For example, in our recent neuroscience study, students brainstormed all the questions they could think of for the topic of neuroscience. Nothing was edited. All of their questions were written quickly as they called them onto a large sheet of butcher paper. Four large sheets, front and back, finally exhausted all of the class's ideas and questions.

This process starts with what students know and begins to make a connection between their past and current learning. The teacher stimulates students by asking questions. This creates both a desire and a requirement for students to learn. Suddenly, their interest is piqued about a topic that they needed to have defined at the beginning of class. Students have connected, linked, and built on one another's ideas to create a huge map of inquiry.

The second step individuates the questions by asking students to describe their personal interests. They generate three to five individual wonder questions, either using the brainstorm questions or posing additional questions. For example, the questions from the neuroscience unit included:

- What controls our dreams?
- What controls our voice boxes?
- Why do you sometimes understand things in the morning that you hadn't gotten before?
- How does your brain know to turn around the picture you see?
- How do your eyes see?
- What are dendrites? the cell body?

the axon? What are these things made of?

- How do memorizing things and memory work?
- To connect eye sight and touch, does the message have to go through the brain or are things connected in passageways?

*Categorizing* questions is the third step. As a class, students begin to group questions and make categories for those questions. They discuss why a particular category is a good idea and defend their choice of category before the group with substantive reasons—otherwise the group may not accept the category. In this process, students eliminate questions with the same idea and generate new questions and categories. More work in this process usually adds categories that were left out in the previous work session or extend the questions or categories.

In the fourth step, the whole class, collaborative teams, and individuals and their families at home *explore* questions. They look for the most or least interesting, the easiest or hardest or impossible question to answer, and they try to determine how long it would take to answer particular questions: one second or a millennium? During our

neuroscience unit, for example, we were fortunate to have Dr. Keith Black, the head of the Neurosurgery Institute at Cedars-Sinai Medical Center in Los Angeles, visit our class to lecture and conduct a “brain lab.” During a questioning session, one student asked Dr. Black, “What controls the mind?” Dr. Black calmly looked at the class. “I don’t know,” he said quietly. “That is one of my questions that hasn’t yet been answered.”

Students next *explore* science through discussion, experiments, field trips, expert visits, reading, and research in groups, as a class, and as individuals. They begin to *explain* and hypothesize about answers. They choose an area of interest and begin to articulate their questions even more. They may write their questions, and these are affixed to a metal grate that literally “hangs over their heads” for the rest of the project. The teacher provides resources for the inquiry, including books, guest lectures, demonstrations, lessons, discussions, and Internet resources.

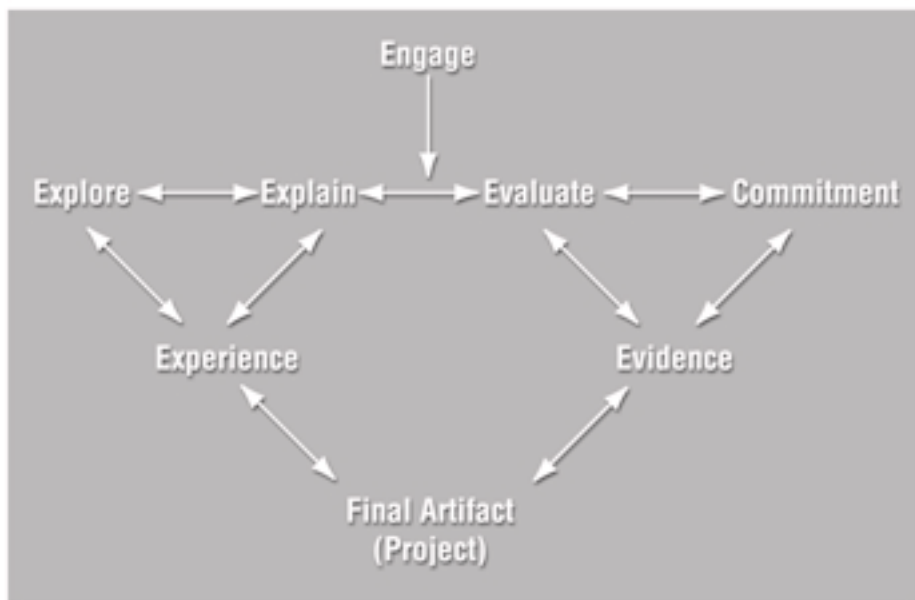
As students work on their projects while refining questions, they are attempting to explain without telling. They are trying to show their understandings as they develop. As they

*experience* more of the science and resources, they develop understandings and discuss ideas and problems as a class and in their groups.

The teacher in this environment continually asks students guiding questions as they explore, experience, and explain. The teacher may help students by providing explanations and introducing terminology at appropriate times (when students have had experience to connect the term). When students want to know about a particular topic, the teacher may provide small-group, half-class, or full-class optional or mandatory lessons, depending on how well students seem to be understanding the topic.

The teacher is the climate creator, the one who initiates the powerful climate of inquiry and pushes students into new realms of questions. The teacher doesn’t need to know all the answers, but he or she needs to be willing to model “finding out” behavior. As the teacher pushes the envelope further and further, he or she provides the environment in which students can explore issues, question, process information, form opinions, make judgments, and become aware of differing viewpoints. Students learn that questioning is valued. Their questions become the vehicles that drive them to deeper understandings as they further explore and experience. For example, as I continually demonstrated valuing *all* questions, not just “right” questions, my students delved deeper and deeper into neuroscience.

During the project, students present their group work twice to the entire class. Their projects—that is, simulations that explain science concepts without telling—are constructed to teach younger children and are in process and need ongoing *evaluation*. The students develop a rubric for evaluating each other during class discussions. The rubric is then continually evaluated during the different sessions.



Students work through the steps in the process many times before they complete their projects.

Its final version is used at the end of the project as students evaluate their own and others' projects.

As the project continues, student inquiry drives the instructional process. Students support each other's understandings as they articulate their observations, ideas, questions, and hypotheses. They explore, experience, and explain as they construct their projects in collaborative teams. They continually ask, "How does this new science experience or understanding affect your questions and research?" They do research, ask experts questions by e-mail, and articulate the experts' answers to the class as they discuss their new conceptual understandings. The teacher continually scaffolds the learning with additional questions that tweak understandings and research in new directions. These also may generate new questions.

Students also ask for *evaluation* from their intended users—students a year younger. The third-grade class comes into the classroom to see the projects twice during their development. Before each visit, students meet to discuss and articulate their project goals, and they generate, evaluate, and eliminate questions for the users. After the third-grade visits, students debrief the interview process to determine which questions did or did not elicit the most helpful answers, what information was gleaned from the interviews, and what effect that information will have on the project's direction. Students debrief as a class, in groups, and individually with quick writing assignments immediately after the visit.

During the project, students are developing their own personally meaningful driving questions; these questions epitomize their interests and research. In class discussions, criteria for questions are given, students make public

statements about their evolving questions and research, and they receive class feedback on whether their questions fit the criteria for scientific inquiry. They begin to defend and give *evidence* for their questions and research design. The teacher continually asks more questions to explore these avenues during class discussions. The evolution from wonder questions to driving question requires wonder time, science experiences and lessons, discussions, group work, expert contact, and question-defining meetings with the teacher individually and in groups.

Approximately six weeks into a 10- to 12-week project, the students are required to commit to a specific research question during a class "roast." Preparation for the roast includes discussions with their groups and the teacher. During the roast, students are in front of the class with their groups. They individually articulate their *commitment* to a driving research question, a research plan, and final project visualization. They must defend their question, plan, and project ideas to their class peers. The rest of the class requires the student to be specific about the details, articulate clearly, and visualize specific project elements. This is a supportive environment, and during the roast students will laugh as they ask students to articulate what they will do as they require clear and specific commitments. The commitments are written down in contract form, and the students sign their commitments, including the date each project is due.

As students continue to work, the spiraling cycle of project construction, scientific inquiry, collaborative work, and science concepts continues. The cycle of questioning, research, and questions continues. Students verify the correctness of concepts with peers, teacher, and resources.

At the end of the project, the students again *evaluate* their rubric, readying it for final use. Student projects are on the computers, and each group rotates to see every other group's work. Each student holds the rubric and an evaluation sheet for each project. They write their comments clearly. Peer comments during evaluation may cover science concepts, computer programming, questions, and whether the project fit the intended research requirements.

## Conclusion

The never-ending story continues. The learning process is open-ended and open to continual change. It is an ongoing loop. The questions students ask lead to answers, which lead to more questions, and more answers that generate more questions. The predetermined and student-driven instruction teaches students that science is a process to be experienced, not a collection of facts. They learn that science is an exciting, multidimensional learning process with its own intrinsic motivations and rewards. The story goes on and on. The teacher tells the students that although the projects are due today, they are also like all projects—still in process. The story never ends, and, I hope neither do the questions. ■

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## Resources

Cocoa is available at [www.crim.ca/~hayne/Cocoa/or](http://www.crim.ca/~hayne/Cocoa/or) [www.stagecast.com](http://www.stagecast.com).

MicroWorlds is available from LCSi, PO Box 162, Highgate Springs, VT 05460; 800.321.5646; fax 514.331.1380; [www.lcsi.ca](http://www.lcsi.ca).

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