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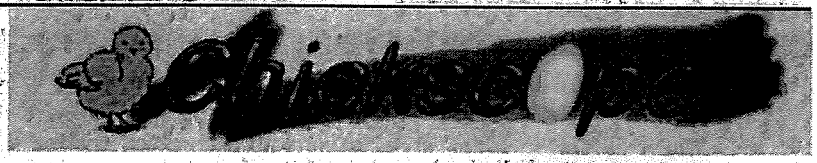
INQUIRY-BASED LEARNING AND TEACHING WITH NEW TECHNOLOGIES



Many educators today are talking about inquiry-based teaching and learning, with a wide variety of conceptions of what that really means. They also have many concerns about how to promote learning through inquiry given the many constraints on schools and the diverse demands that teachers face. Let's start with the working definition (from Barry Beyer, 1971, p. 6) that inquiry is

> one way of making sense out of what we experience ... Inquiry teaching is putting learners into situations in which they must engage in the intellectual operations that constitute inquiry. It requires learners to make their own meaning out of what they experience.

Thus, teachers strive to create a student-centered classroom, where students' questions and problem-solving abilities drive the curriculum, and where they have the opportunity to reflect on their own learning. Then, a number of key questions arise:

1. How do we get students to engage in inquiry?
2. How do we ensure that ALL students are involved in inquiry activities?
3. How do teachers link to other teachers and student teachers to facilitate inquiry learning and teaching?
4. What are the roles for scientists in supporting inquiry in the classroom?
5. How can teachers study their own inquiry practice and share what they learn with others?

We describe here a project in which K-12 teachers worked together to address these questions and to develop practical methods for supporting inquiry in the classroom. The professional development model we developed could be useful for other emerging technology projects.

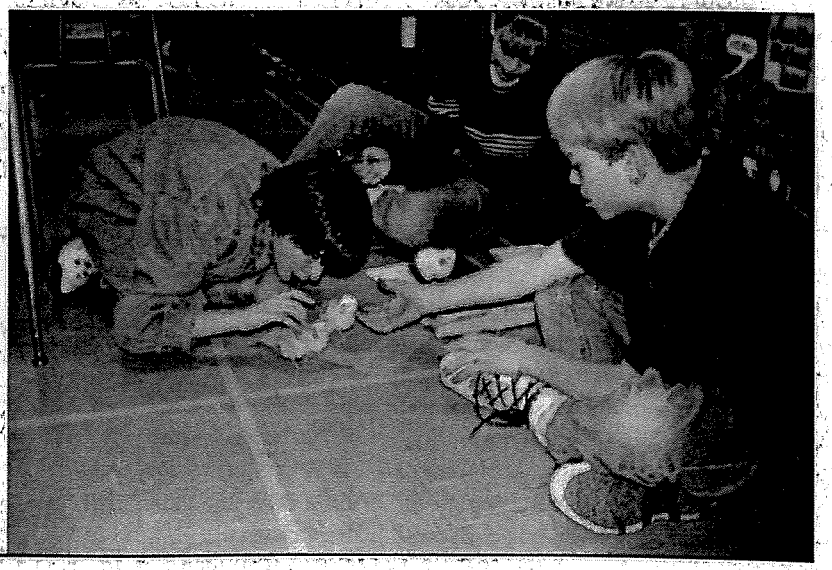
Chicken eggs + MRI = Chickscope

The Chickscope project http://chickscope.beckman.uiuc.edu was initiated at the University of Illinois at Urbana-Champaign by Clint Potter and scientists across eight departments (see Acknowledgements). Chickscope allows students to study chicken embryo development using a variety of educational resources, such as inquiry-based curriculum materials, egg incubators, interactive modules on egg mathematics, image processing, and a remotely-controlled magnetic resonance imaging (MRI) instrument. Participating classrooms incubate fertile chicken eggs, look at MR images of developing embryos, and share their inquiries with students and teachers in other classrooms.

As Kristen Morris, a seventh- and eight-grade mathematics teacher at Urbana Middle School says,

> Chickscope is a multi-dimensional project which incorporates many kinds of learning. It includes web based learning and discovery, hands-on science experiments, and the ability for students to interact with scientists. It is a wonderful project.

An evaluation report documented that the first Chickscope project in 1996 was successful in immersing students and teachers in a scientific community (Bruce, et al., 1997). Students and teachers learned how to collect and analyze data, how to ask questions, and how to communicate their findings with others. Since the completion of this project we have had inquiries from around the world asking if the project would be repeated and requesting access to the resources and expertise. Responding to this early success, we initiated an Eisenhower Professional Development Program for K-12 teachers.



Professional Development

The professional development program began with the introduction of Chickscope to 57 preservice teachers in the fall of 1997 through a month-long unit on chicken embryo development. These teachers then took their new pedagogical knowledge into their student teaching. During the spring semester, 32 K-12 classroom teachers from 15 schools in Champaign, Clark, and Coles counties participated. These inservice participants learned about Chickscope during five inservice days. As Brenda Foster, a fifth-grade teacher at Dr. Howard Elementary School, Champaign says,

> I feel that this project provided me with lots of background information as well as resources for using chicken embryology in the classroom at my grade level. The MRI data base and the Chickscope homepage offers a variety of resources that I can use.

During a week-long summer inservice, the teachers used these resources to develop inquiry-based curriculum materials for their own classrooms. The teachers returned for one day of inservice in the fall 1998 semester to introduce the project to new preservice teachers and other interested teachers. Each inservice session included interactive discussions, hands-on and computer-based activities related to chicken embryology, mathematics, and MR imaging. The project continued in a similar way in 1999 with a second cohort.

The workshops included experienced teachers from primary grades, upper elementary, middle school, and high school, as well as preservice elementary teachers. Graduate students both assisted in and learned from the project. Faculty and university staff from diverse departments shared their knowledge and worked with the teachers to develop inquiry-based activities.

Evaluation Methods

Although early experience with Chickscope suggested that it could be beneficial in the classroom, the idea of extending it to larger numbers of teachers was unproven. Many issues arise (e.g., Loucks-Horsley, Styles, & Hewson, 1996) in the attempt to move beyond the original innovators and deal with the realities of diverse classrooms. In our research, we asked whether Chickscope could fulfill its original objectives, to

- Engage preservice and inservice teachers in substantive professional development for inquiry-based mathematics and science teaching.
- Support continuing learning by teachers in the classroom through reflection and collaborative curriculum development.
- Promote a model for successful classroom implementation in the areas of mathematics, science, and technology.
- Support collaboration among classroom teachers, preservice teachers, and content experts.
- Develop a community of learners to scale up the project.

A variety of data was collected for the evaluation, including answers to survey forms administered at the end of each session, classroom observation data, and teacher-constructed web sites, now available on the Inquiry Page for any teacher to use. Both formative and summative evaluations were conducted, with the results presented by teacher participants as well as by project staff at conferences including Supercomputing '98, the American Educational Research Association, and the Illinois Science Teachers Association. Formative evaluations of the Chickscope and the Inquiry Page web sites are also being conducted.

Participation in Professional Development

One or more teachers from each of the participating schools attended throughout the project, with an average of 24 teachers in attendance at each session. School administrators would not always allow all the participating teachers from to leave at one time, especially at the high school level.

Each inservice session included interactive discussions, hands-on, and computer-based activities related to chicken embryology, mathematics, and MR imaging. Illinois Chickscope built a community of teachers; linked that community with scientists in a variety of disciplines; promoted an integrated understanding in science and mathematics; and taught new ways of using the Internet.

In several schools, participants brought their colleagues into the project. These included librarians, science specialists, technology coordinators, and art teachers, as well as other regular classroom teachers. Over two years, the project involved around 40 teachers from 17 schools, 150 preservice teachers, 2000 students, and many others. Counting unofficial participants–parents, family, farmers, university faculty and graduate students–several hundred people were involved in significant ways and learned from the project.

Continued Learning by Teachers

Teachers attending the inservice during the spring semester had opportunities to give input on the program as well as reflect on their participation through online forms. Most teachers found the Illinois Chickscope inservice visits "very useful" to their classroom teaching. For example, a teacher who developed an activity about fertile and infertile eggs for her third- to sixth-grade students said:

> *Chickscope means bringing life and interest into the lives of several children. It means giving students something exciting to learn about and do in school. It means giving students an opportunity that they might not otherwise have. Chickscope means giving students additional technical skills and knowledge both about computers and about science. Chickscope has meant a lot of things to me. It has encouraged me to think differently about teaching and about learning. It affirmed for me that it is okay to do things that aren't necessarily normally done. For instance, hatching chicks in the computer room is not something that is done every day.*

It amazed several students, parents, and community members that we did hatch chicks in the computer room but it also helped show those connections in real life science that aren't always seen. Chickscope brought a lot of excitement and fun to my classroom and to my students. I have thoroughly enjoyed it and plan on using the information I have gained from it a lot in the future. –Tara Allen, Marshall North Elementary School, Marshall

However, the spring and summer inservice visits were not enough for most teachers to fully integrate Chickscope materials into their classrooms. One reason for this is that Chickscope has resources that are applicable to different subject areas–even social science, language arts and art–across K-12. Consequently, teachers needed ample time to not only to familiarize themselves with the Chickscope resources, but also to share curriculum ideas with each other.

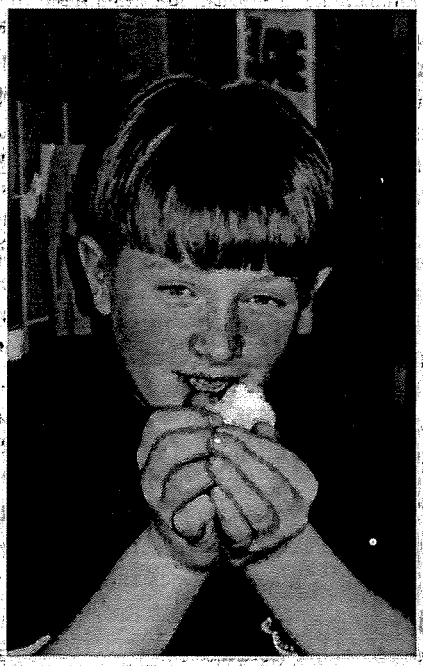
Another reason is that teachers who have developed curriculum materials that are still works in progress need additional time to continue working by trying out these materials initially in their classrooms with small student groups. For example, a fifth-grade teacher who worked with a fifth-grade teacher from another school on a curriculum project about investigating vertebrates said:

I feel that this project provided me with lots of background information as well as resources for using chicken embryology in the classroom at my grade level. The MRI database and the Chickscope homepage offers a variety of resources that I can use. – Brenda Foster, Dr. Howard Elementary School, Champaign

Teachers shared their growing knowledge through curriculum units, lesson plans, and classroom stories that have been posted on a new web site, called *The Inquiry Page* <http:/ /www.ed.uiuc.edu/inquiry/>. This web site has been recognized for its potential as a resource for both preservice and inservice teachers for a variety of projects like Chickscope.

Classroom Implementation

A detailed situated evaluation of classroom implementation of the Chickscope ideas is given in Hogan (1999). Here, we briefly report on one classroom as an exemplar of the kinds of changes we documented in the project.



In mid-March of 1998, one of us (Maureen Hogan) observed in two sixth-grade classrooms at Hawthorne Middle School in Mattoon, Illinois, where Illinois Chickscope teachers were incubating chicken eggs. The field notes and analysis of documents indicate that students improved knowledge, skills, and attitudes toward science because of the program.

Specifically, the teachers' inquiry-based science curriculum helped students learn scientific method and measurement. During the 21-day incubation period, the students observed eggs, candled them, and made predictions about their development. They also learned about incubation, a process that requires careful administering in order to ensure successful hatching: not bumping the incubator, turning the eggs regularly, carefully monitoring temperature and humidity, were all important lessons.

When the chickens hatched, students named them, identified their breed, weighed and measured them at two-day intervals and charted their age and growth. Charting growth was not always easy for children to do, because chickens move around a lot. The children discovered that they had to weigh and measure the chickens more than once in order to get a satisfactory reading.

As a result of this project, the students' knowledge and skills about embryology, incubation, the scientific method, and measurement improved. Most remarkable, perhaps, was an improvement in their attitudes toward science, as indicated by their level of involvement. Children unsolicitedly helped in incubator management and chick care. The sixth graders were so excited about this project that they often came in early and stayed late to care for their chickens. They invited their parents and grandparents to their classrooms to see the project. One parent told a Chickscope teacher that her child was more excited about the hatchings than about Christmas!

Interaction with Content Experts

In general, all teachers were appreciative of the opportunities to interact with experts from different disciplines during the Illinois Chickscope inservice visits. For example, excluding the project staff and students who worked closely with the teachers, there were over 15 experts who gave presentations and interacted with the teachers during the spring and summer semesters. In their final feedback, more than half of the teachers volunteered that the expert speakers provided them with new science information, encouraged them to inquire further, use new skills, apply it to instruction, and share what they learned with their colleagues.

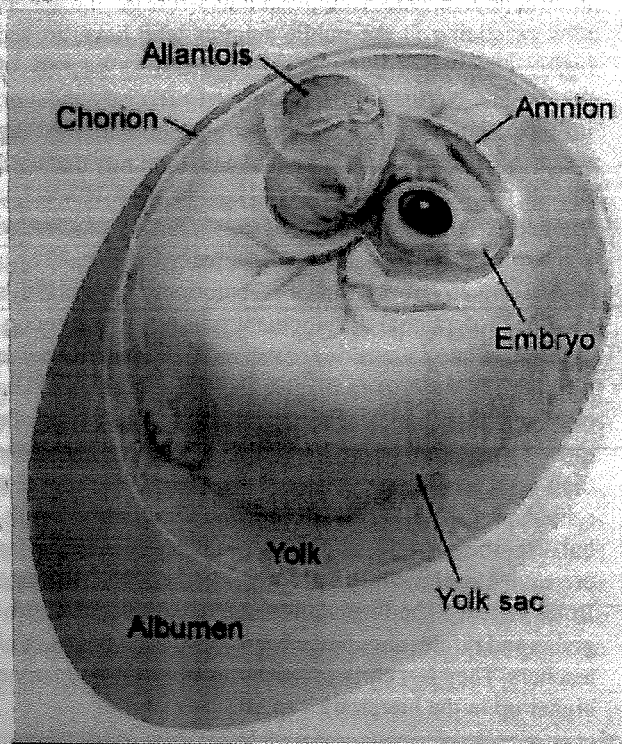
As a result of these interactions, the main Chickscope web site underwent extensive revision and expansion during the project. A major unit on egg mathematics was added along with an interactive database of MR images. Information about chicken breeds, poultry farming, embryology, imaging technologies, chemistry, genetics, and many other areas of science and social science have been incorporated. The site receives over a hundred visits a day from around the world.

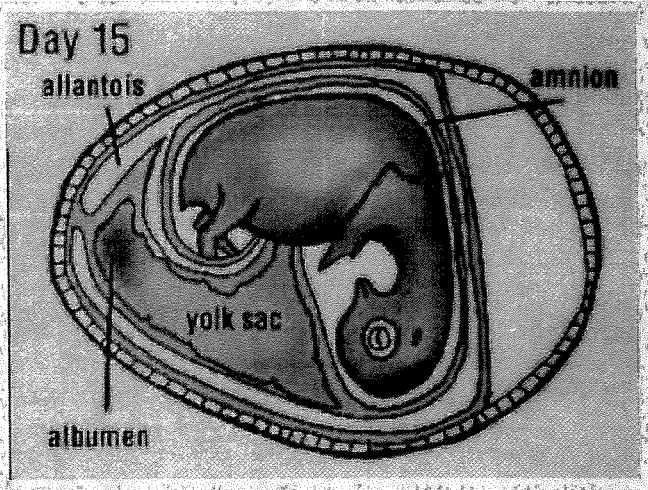
Community for Learning

During the inservice, especially during the summer, the teachers focused on a broad question: How do we build a community for inquiry learning?

It was critically important to include teachers in the dialogue about inquiry-based learning and teaching. Each day in the summer inservice began with one of the inquiry questions listed above to guide the discussion as well as the design and development of curriculum materials. Teachers developed personal definitions for inquiry. One teacher said that inquiry learning refers to a "process to stimulate students' critical thinking skills in which the teacher serves as a facilitator. It helps encourage a desire for learning, and problem solving." Sabra Culp, a sixth-grade teacher from Hawthorne Middle School, Mattoon, who constructed a Chickscope unit on measurement with Clyde Self, pointed out how important it was to learn from one another:

> I feel that the group (instructors and participants) feel comfortable in sharing their successes and problems. We certainly are learning from each other, as well as being provided with material (some applicable, some not) that we as professionals have to evaluate to see if it fits our needs.





Indeed, building a supportive teacher community to discuss inquiry-based projects was the centerpiece of the Chickscope inservice.

Conclusion

In sum, Illinois Chickscope built a community of teachers; linked that community with scientists in a variety of disciplines; promoted an integrated understanding in science and mathematics; and taught new ways of using the Internet.

The project has been described favorably in a variety of news media, including *The News-Gazette* (in news, education, and agriculture sections), *Inside Illinois, info.ed, The Marshall Choice Independent,* and WOR-TV. See attachment for the complete list of Chickscope publications and presentations.

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Acknowledgements

Chickscope has been developed by educators and researchers from eight university units in collaboration with inservice and preservice teachers. Participating University of Illinois units include Animal Sciences, Beckman Institute Visualization Facility, Biomedical Magnetic Resonance Laboratory, Curriculum and Instruction, Electrical and Computer Engineering, Mathematics, National Center for Supercomputing Applications, and Veterinary Biosciences.