SRA
Open Court

Professional Development Guide

Inquiry and Investigation

Author
Carl Bereiter

SRA
A Division of The McGraw·Hill Companies
Columbus, Ohio

Photo Credits:

p 1, ©Bill Aron/Tony Stone Images; **p. 3,** ©Stephen Derr/Image Bank; **p. 4,** ©Jonathan Meyers/FPG International; **p. 5,** ©Mary Kate Denny/Tony Stone Images; **p. 7,** ©Chip Henderson/Tony Stone Images; **p. 8,** ©Kindra Clineff/Tony Stone Images; **p. 10,** ©Rhoda Sidney/PhotoEdit; **p. 12,** ©Jean-Claude LeJeune/Stock Boston; **p. 14,** ©Peter Beck/The Stock Market; **p. 15,** ©Peter Cade/Tony Stone Images; **p. 16,** ©Jim Cummins/FPG International; **p. 17,** ©Bill Bachman/PhotoEdit

www.sra4kids.com

SRA/McGraw-Hill
A Division of The ***McGraw·Hill*** *Companies*

Copyright © 2002 by SRA/McGraw-Hill.

All rights reserved. Except as permitted under the United States Copyright Act, no part of this publication may be reproduced or distributed in any form or by any means, or stored in a database or retrieval system, without the prior written permission of the publisher, unless otherwise indicated.

Send all inquiries to:
SRA/McGraw-Hill
8787 Orion Place
Columbus, Ohio 43240-4027

Printed in the United States of America.

ISBN 0-07-571264-4

1 2 3 4 5 6 7 8 9 MAL 05 04 03 02 01

Table of Contents

Inquiry and Investigation

Research Through Inquiry and Investigation

Adults sometimes read simply to enjoy a good story, an intriguing biography, or a beautifully crafted poem. Most often, however, adults read to gain specific knowledge. Adults read to find information on a range of topics, from tax laws to lawn mower repair; from who won the state high school basketball championship to who won this year's Noble Prize for Medicine; from who was President of the United States during the Spanish American War to who is the chairperson of the state board of education. This ability to read to find out what is needed or what is desired to be learned is a hallmark of scholarship.

> ***This ability to read to find out what is needed or what is desired to be learned is a hallmark of scholarship.***

At the elementary school level, language arts instruction traditionally is isolated from the world of scholarship. In addition, instruction in reading, writing, speaking, and listening is often fragmented and lacking in a coherent plan that allows students to *work with knowledge*. For example, instruction often centers on themes, which are little more than topics covered in a hit-or-miss, superficial manner. The information about a theme that students acquire from reading one book or selection may not necessarily relate to the information they find in reading the next book or selection. Writing assignments focus on simple read-and-report activities rather than on ways to help students gain information that they can use over time to construct an understanding of the world.

This guide describes the procedure used in ***Open Court*** to help students conduct research within their language arts instruction. The procedure involves students in inquiry and investigation as ways to introduce them to the world of scholarship and to prepare them for lifelong learning.

How Does the Inquiry/Investigation Procedure Differ from Conventional Research Instruction?

In conventional elementary school classrooms, *research* generally means having students collect information and prepare a paper. They

conduct their research by following a procedure that usually involves a series of steps such as the following: (1) select a topic, (2) narrow the topic, (3) collect materials, (4) take notes, (5) organize notes, (6) make an outline, (7) write the paper, and (8) present the paper.

Topic selection usually means choosing from a list of topics suggested or directed by the teacher. The remainder of the steps usually require students to locate encyclopedia entries or articles easily found in a library or on the Internet—then write down information from them (Schack, 1993).

Although this procedure may result in the preparation of an adequate paper, it does not constitute *research* in any meaningful or useful sense. Indeed, it gives students a distorted and depressing idea of what real research is all about.

Ample evidence exists that elementary school students *can* do descriptive, historical, and experimental research that seeks answers to real questions or solutions to real problems (Schack, 1993). To do this kind of work, however, students need a better research procedure than the one provided by the traditional approach.

The inquiry/investigation procedure is based on the assumption that students can do research that will result in the construction of deeper knowledge.

The inquiry/investigation procedure is based on the assumption that students *can* do research that will result in the construction of deeper knowledge. The procedure presents research as a never-ending, recursive cycle. Like real-world researchers, students produce their own questions, develop ideas or conjectures about why something is the way it is, then pursue the answers. The answers, as for real researchers, may never come. What will come are more questions. Developing the questions, pursuing the answers, developing conjectures, revising ideas, and setting off on new avenues of research and investigation are the stuff of which strong, deep knowledge and expertise are made. The web of knowledge expands in ways that no teacher or student can predict easily.

Translated into instruction, the inquiry/investigation procedure provides enough structure that students do not get lost or bogged down as they explore concepts, while it preserves the open-ended character of real research, which can lead to unexpected findings and to questions that students did not consider originally. To do this, the procedure follows these important principles (Bereiter & Scardamalia, 1993):

- Research focuses on problems, not topics.
- Conjectures guide the research rather than the reverse.
- New information is gathered to test and revise conjectures.
- Discussion, constant feedback, and constructive criticism are important in all phases of the research, especially in the revising of problems and conjectures.
- The cycle of true research is essentially endless, although findings are presented from time to time; new findings give rise to new problems and conjectures, and thus to new cycles of research.

Theoretical and Research Foundations of the Inquiry/Investigation Procedure

The inquiry/investigation procedure is based on analyses of how real-world research proceeds. Its theoretical foundations can be found in the work of John Dewey (1997) and Karl Popper (1992). Of particular importance to this approach are Dewey's views of experience, interaction, reflection, and his belief that

learning by doing is more productive than rote learning and dogmatic instruction. Another important support for the procedure is Popper's idea that knowledge can grow only through a process of trial and error—that learning is a series of experiments in which different ideas, theories, and ways of thinking are tried, and those that do not satisfy needs or goals are rejected.

The inquiry/investigation procedure is equally grounded in cognitive science research—the study of how humans think and learn. Teaching methods based on cognitive science have been called "the educational equivalents of polio vaccine and penicillin" (Bruer, 1993). These methods have produced results such as the following:

- sixth-grade students learning conceptual physics better than even eleventh and twelfth graders who were taught by conventional means (White & Frederickson, 1998).
- second-grade students learning to represent geometrical forms in ways that exceeded those used by undergraduates (Lehrer & Chazan, 1998).
- remedial students raising their reading comprehension scores four grade levels after 20 days of instruction (Bruer, 1993).

Among the strands of cognitive science research evident in the inquiry/investigation procedure are the following:

Expert-novice comparisons Expert-novice comparisons look at what experts in a particular field *know* and at what they *do* that novices in the field do not know or do, or do differently or less often than experts (Bereiter & Scardamalia, 1989). These findings are valuable in education because they show what the results of successful learning look like. For example, experts notice features and patterns of information that novices do not see. Experts also have extensive subject-area knowledge, and they organize it in ways that reflect a deep understanding of the subject. They are able to retrieve important aspects of their knowledge flexibly with little conscious effort. Novices lack conscious awareness of their mental processes. Further, they lack strategies for carrying out mental tasks (Bereiter & Scardamalia, 1993; Bransford, Brown, & Cocking, 1999).

Metacognition Novices, in fact, are novices precisely because they have not become consciously aware of the knowledge they already possess and of themselves as problem solvers. They lack the strategies to monitor and control their own thinking (Brown, 1987; Brown, Bransford, Ferrara, & Campione, 1983; Giere, 1991); that is, they do not engage in *metacognition*.

Almost by definition, students are universal novices, faced constantly with new learning tasks. The aim of instruction, therefore, should be to help students to be *intelligent* novices. Intelligent novices are those who, although they do not possess knowledge of a particular subject, know how to get that knowledge. They have learned how to learn from texts rather than how to memorize facts (Brown & Campione, 1990).

Schema theory Expert-novice comparisons serve to underscore the important role that prior knowledge plays in learning. Indeed, one of the most basic insights of learning is that it depends to a large degree on prior knowledge (Anderson & Pearson, 1984; Brewer, 1989; Vosniadou, 1991b).

> *... one of the most basic insights of learning is that it depends to a large degree on prior knowledge.*

It also appears that the *system* of understandings, or knowledge structures, that a student brings to learning about a concept is more important than facts he or she may know or not know. This view of learning is known as *schema theory* (Anderson & Pearson, 1984). According to schema theory, knowledge (*schema*) is a huge network of abstract mental structures that represent our understanding of the world. A general category of schema includes slots for all the features included in the category. Each of us has many *schemata* (plural). Relationships among our schemata are like webs, with each schema interconnected to many others. Schemata grow and change as new information is acquired through experience and reading.

Naïve theories Research has revealed that even when it appears that students do not know anything relevant about a concept, they are applying their own theories about the concept. These personal, or *naïve,* theories are sets of ideas that students develop as a way to make sense of the world around them and, in particular, of the things adults or those viewed as experts tell them (Vosniadou, 1991a, 1991b).

Because they already have developed naïve theories of particular concepts, students may find experts' explanations of these concepts confusing. As a result, they often distort the expert explanations in order to align them more closely with a naïve theory. Some students also may compartmentalize—that is, they may use the version of the expert theory for school but keep their own theory for life outside of school (Vosniadou, 1991a, 1991b).

To illustrate, young students may come up with dramatic misconceptions about concepts such as the shape of Earth, the size of the planet, and so forth, even after teachers and other adult experts provide them with scientific explanations of the concepts (Vosniadou, 1991b). Instruction, therefore, should take into consideration that students may bring to a concept many misconceptions. These misconceptions must be identified and addressed before they can be replaced with accurate explanations.

Reciprocal teaching In *reciprocal teaching*, the expert/teacher first models and explains a set of cognitive activities, such as the steps involved in conducting research. The expert then begins to turn over parts of the learning activity to the novices, but only at the level that each one can negotiate at any one time. As the novices become more competent, the expert requires their participation at increasingly more challenging levels (Palincsar & Brown, 1984).

Joint cognitive process model A *joint cognitive process* is a single process with different parts carried out by different people (Bereiter & Scardamalia, 1989). In the classroom, this model is used to create a community of scholars—one that works together much as a community of scientists or scholars works in real-world settings (Matthews, 1994). The community members must work cooperatively to develop a consensus about what concepts to explore and how to conduct the inquiry or investigation. In the community, all members are involved explicitly in a reflective, social process that brings multiple perspectives to the analysis and evaluation of their work processes and the products of their investigation (White & Frederickson, 1998).

What Does the Inquiry/Investigation Procedure Look Like in the Classroom?

In the classroom, the inquiry/investigation procedure takes students through a recursive cycle that involves many steps. Students may go through these steps several times before they come to the end of their research. In real research the cycle can go on for years, and in some cases for lifetimes.

The steps in the recursive cycle of research are:

1. Decide on a problem or question to research.
2. Formulate an idea or conjecture about the problem.
3. Identify needs and make plans.
4. Reevaluate the problem or question based on what has been learned.
5. Revise the idea or conjecture.
6. Make presentations.
7. Identify new needs and make new plans.

Real research is not motivated by a general interest or by curiosity about a topic. It is motivated by a problem or question.

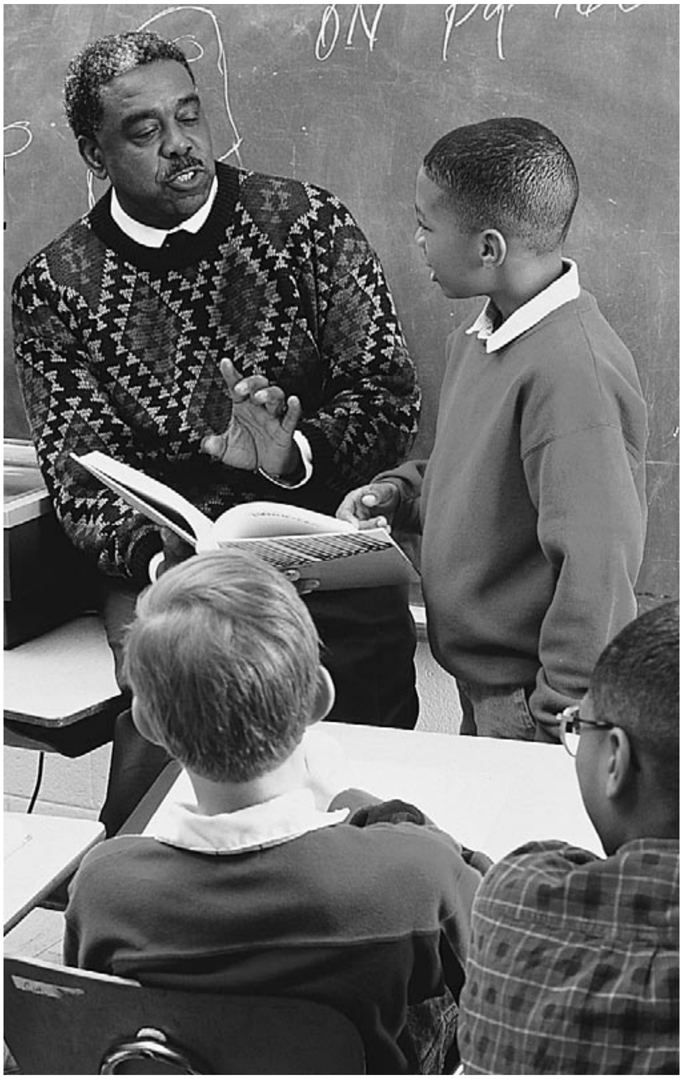
Step 1: Decide on a problem or question to research. Real research is not motivated by a general interest or by curiosity about a topic. It is motivated by a problem or question. Being interested in a topic helps, because it leads to the identification of better problems and to more motivation to pursue them.

When the procedure is first introduced, students may require some help in formulating problems or questions, especially if they are accustomed to doing conventional, topic-centered research for the purpose of writing papers. For example, a student who has written only on topics such as "meteors" or "crocodiles," and who was rewarded for this work with praise and good grades, will be tempted to tackle similar broad topics. It is easy to find information about broad topics. It is also easy to divide this information into categories, then turn it into an encyclopedia-style paper. If these students are urged to formulate a question or problem, they might come up with something like: "What is a meteor?" This is merely a broad topic with a question mark.

In the inquiry/investigation procedure, students generate problems and questions after some discussion but *before* they have had a chance to consult encyclopedias and other reference materials. This approach tends to bring out ideas the students wonder about or wish to understand. In contrast, if students consult reference sources before discussion, they are likely to come up with questions that the reference source already has answered or problems in which they have no real interest. For example, if they first consult encyclopedias or textbooks, students who generate problems related to the concept of astronomy are likely to produce standard questions, such as "How were the planets formed?" or "Will we be able to travel to other planets?" Such questions are fine except that the reference sources already have answered them. With the answers right before them, students may be tempted merely to copy or paraphrase what the sources say. It is true that students can pursue the questions in depth if they are truly interested in answering them. It cannot be assumed, however, that students who select such questions *do* care much about answering them.

The questions that students really wonder and care about tend to be different from those just mentioned. Furthermore, they are more challenging to research. Let's say that students come up with an astronomy-related question such as "Why are planets round?" They will not readily find a direct answer to this question. Instead, they will need to investigate several different sources that describe how the planets were formed. As they encounter references to "whirling balls of molten material" and find meteorites described as "pieces of material thrown off by spinning planets as they were forming," students may begin to formulate an explanation of why planets are round. As their explanations begin to form, they are led to ask new questions and follow new lines of inquiry, and possibly even to conduct experiments that involve spinning bodies.

Having students generate problems or questions before consulting sources has the advantage of bringing their own conjectures into play and of revealing any naïve theories they may possess. Young students often ask questions that show their naïve understanding of how things work. Questions such as "What is gravity made of?" and "What keeps the gravity inside Earth?" reveal the naïve belief that gravity is a *substance*—something that can be seen



and touched. Because these questions are based on false premises, they are unanswerable. However, encouraging students to investigate their questions can bring their beliefs more in line with the scientific understanding of what gravity is—that it is not a substance; indeed, it is not an identifiable *thing* at all. They may be pleased to learn that this bothered Isaac Newton just as it bothers them.

If students are investigating a concept that they already know something about, they can start immediately to discuss things they question, want to understand, and so on. If the concept is unfamiliar and the students have little related prior knowledge, then some teacher-directed introduction is needed to stimulate and provide a basis for questioning. A videotape, a story, a movie, or an account of personal experiences may provide the basis. For reasons given already, however, the introduction should not be an encyclopedia-style overview of the concept, even if it is enlivened by video.

What kind of introduction, if any, to use depends on the students as well as the concept. In some classes, students already will have a good deal of information and many ideas that are relevant to the concept. If this is the case, they should start right in on discussion and problems. It does not matter that their information and ideas may be spotty or mistaken. What does matter is that students have *enough* accurate information to start their thinking. If students who are exploring astronomy have no notion of the cosmos, except as given in space fantasies, or if those exploring the American Colonial Period have never heard of the pilgrims or the Revolutionary War, they will need teacher-directed introductions to help orient them and to provide them with anchors for their subsequent inquiry.

> ***It takes patience and effort to shift the criterion of success from answers to progress, but it is an important move toward building a community of scholars.***

Occasionally, students may select problems that are too hard for them. This is sure to happen if being "too hard" means that students cannot find definitive answers to their questions. Given this definition, most real research questions are too hard. When this occurs, teachers should remind students that the criterion of success is not finding answers but making progress. As noted previously, traditional schooling is based on question-answer dialogues. Students and teacher alike come to believe that success is measured only by correct answers. It takes patience and effort to shift the criterion of success from answers to progress, but it is an important move toward building a community of scholars.

Step 2: Formulate an idea or conjecture about the problem. How can students judge their progress in researching a problem? The response is not by how close they are to the answer, because this assumes they already know what the answer is. Progress is better demonstrated when a student can say "Here is what I thought when I started, and here is what I think now. What I think now is better than what I thought before in the following ways . . ." and then provide some reasons. Thus, conjectures—initial conjectures and revised conjectures—play a central role in inquiry/investigation research. In fact, *the purpose of research is to improve conjectures.*

> ***It is not expected that students' initial conjectures be well founded, although it is expected that their later conjectures be better founded and thus evolve toward hypotheses or theories.***

Why is the term *conjecture* used? It seems to be an unnecessarily difficult term to use with young students. Why not use *theory, idea, belief, opinion*—or, if using technical vocabulary, *hypothesis?* The term *conjecture* is used because (1) it is the most precise term in context of the inquiry/investigation procedure, (2) it has a respectable place in the philosophy of science, and (3) it is a good idea to use technical vocabulary with children when certain terms are going to be used frequently and when everyday language does not offer entirely adequate substitutes. The term *theories* implies something more elaborate and formal. *Ideas* is too broad and covers too many possibilities. Further, it is possible to entertain a conjecture without holding it as a *belief* or *opinion* (an important point to convey to students). *Hypothesis* is the most closely related term for this concept, but it implies a well-founded conjecture that already is based on evidence. It is not expected that students' initial conjectures be well founded, although it is expected that their later conjectures be better founded and thus evolve toward hypotheses or theories.

Students sometimes resist making initial conjectures, arguing legitimately that they do not know enough about a concept to make good ones. The appropriate response to this is

"Make the best conjecture that you can. If you already have an idea of what is wrong with your conjecture, so much the better. That will give you a head start on improving it." The point to emphasize is that the goal of the research is to improve conjectures. For that to work, there must be a conjecture to start with.

Step 3: Identify needs and make plans. At this step, students identify the knowledge and resources they will need to address their conjectures. They then make plans about how to obtain the needed knowledge, information, and understanding.

Identifying needs and making plans can proceed in two ways, depending upon the students. Younger students might be encouraged to discuss questions that are related to the problem to be researched. Discussion can keep students from focusing on one key word and alert them to a wider range of relevant information. Older students, however, should begin by asking themselves what they need to know.

In one instance, a student proposed "the heart" as a research problem. Told by his teacher that "the heart" is a topic and not a problem, the student came up with a new question: "How does the heart work?" Although this is a researchable problem, it is one that is likely to encourage the student to lift material directly from reference books. When the student had to identify his knowledge and information needs, however, he produced the following: "Why does the blood have to circulate? Why can't it stay in one place?" That is a question that is truly fundamental to understanding the circulatory system. It gives an important scientific direction to research that otherwise might have been entirely descriptive.

Step 4: Reevaluate the problem or question based on what has been learned. At this step, students gather new information, guided by their research problem, conjectures, information needs, and plans. Depending on the kind of research a student is conducting, she or he may obtain new information from all kinds of sources: print materials, videos, electronically stored data, experiments, observations, interviews, and consultations with experts. This is an exciting part of the research procedure, but it easily can drift away from its purpose.

Students should use the new information they obtain to change their conjectures or reformulate their problems.

The best way to keep the information search purposeful is through frequent reevaluation steps. Students should use the new information they obtain to change their conjectures or reformulate their problems. Indeed, this step may occupy most of the time and effort in the inquiry/investigation cycle of research. In order for this step to serve its purpose, it must alternate continually with the other steps in the cycle, allowing the new information to be processed as new knowledge, new conjectures, and new questions for further investigation.

It is important ... to get students to think about what their information can contribute to the objectives of their research and to that of their classmates.

The word *new* is a major factor in the reevaluation step of the procedure. When students report their findings, they must be prepared to respond to the question "What does this tell us that we didn't know?" or "How does this information help us?" Such questions should not be thought of as negative criticisms but as legitimate queries. Conventional school practices encourage students to recite information, even though it duplicates what others have said, simply to demonstrate what they have learned. It is important, therefore, to get students to think about what their information can contribute to the objectives of their research and to that of their classmates.

> *Knowledge does not come simply from the acquisition of new information. It comes from reconsidering current beliefs and conjectures in the light of the new information and trying to make sense of them in combination.*

Step 5: Revise the idea or conjecture. In research, unlike most other activities, everything is open to revision: problems, conjectures, plans, methods, and even previously accepted facts. Accordingly, the revision step of the cycle has no specific agenda. It is wide open to anything that needs to be changed. However, revision should not be impulsive. Students should have a reason for making changes. New facts, new insights, or new inferences may be a basis for revisions of various kinds. Because there is no specific agenda, it is difficult to provide much structure for the revision step. The important thing is that individual students, research teams, and the whole class have opportunities to meet and consider possible revisions. This is where most of the real thinking and knowledge building will occur. Knowledge does not come simply from the acquisition of new information. It comes from reconsidering current beliefs and conjectures in the light of the new information and trying to make sense of them in combination.

Given its importance, what can teachers do to make the revision step of the research cycle successful? What can they do if it isn't working? This step is largely a discussion phase, so the principles for making it successful are the same as those for discussions in general: constructive commenting, refocusing, seeding, and participant modeling. Beyond that, success of the revision-step discussions will depend on how well the cycle of research as a whole is going. If students are pursuing interesting and interrelated problems and are finding out significant new information, productive discussions should be easy to sustain. Students will be eager to contribute, and new problems and conjectures will arise spontaneously. On the other hand, if students are not bringing much new to revision discussions, no amount of skillful leadership can make them productive.

Discussions need to be focused in ways that will promote revision. If research has been going well, students will be eager for a chance to report what they have found out and not so eager to dwell on what others have found. A reasonable strategy is to let the most eager students report briefly, in order to take that pressure off and then refocus: "We've heard a lot of interesting new information. Now let's talk about what it means. April, you reported some

interesting things about Jupiter. Would you like to start by talking about whether this new information changes your mind about anything?"

Step 6: Make presentations. In conventional research projects, everything is aimed toward the final product—usually a written or oral report, but sometimes a presentation in some other medium such as videotape, demonstration, model, or poster. Presentations play an important role in the professional research world as well, but they have more varied functions and are not limited to a final big splash. In the course of an extended project, researchers will give informal presentations to their colleagues, seminars for other research groups, and conference presentations in the form of separate papers or panel discussions. Along the way, there may be interviews or talk-show appearances. Early versions of reports may be posted on computer bulletin boards or Web pages.

These presentations all contribute to revision. They produce feedback and criticism from peers that may change the research or modify conjectures. They are occasions for the presenters to think through what they have done and what the implications are. A formal research publication has been shaped by its earlier presentations, as well as by the thinking that accompanied them. Most of these values are lost in the conventional school approach, where presentation occurs as the final step of research, after the thinking and learning are over.

> ***Because revision steps are expected to occur frequently, ample opportunities arise for presentations of all kinds.***

In the inquiry/investigation research cycle, presentations are an offshoot of the revision step. Because revision steps are expected to occur frequently, ample opportunities arise for presentations of all kinds. The following is a list of some useful, informal presentation formats. Each is intended to take less than ten minutes, including a few minutes of discussion. (Students may find it interesting that at real-word research conferences, researchers commonly are allotted only six to ten minutes to make their presentations.)

- **Mini debate.** Group members who have opposing conjectures present them, along with supporting evidence and arguments, for class reactions.
- **Video/computer highlights.** A research group presents and comments on short (one minute or less) segments of a videotape or Web site display that group members think will be of value to other research groups.
- **Book or article highlights.** Similar to video highlights, the presenters also read excerpts and offer comments.
- **Preliminary findings.** A group uses graphs and other visuals to help communicate its findings more quickly.
- **Problem presentations.** Groups that are not able to find relevant material or that have found something puzzling or inconsistent present their problem for suggestions.
- **Poster session.** When not enough class time is available for all students who want to present their research, teachers can allot a certain amount of wall space to each presenter to put up whatever kind of display he or she wants—graphs and pictures with captions, summaries in large print, and so forth. At the start of a poster session, each presenter may have one minute to announce the intent of the poster. Then the class is free to study the posters, with the

presenters standing by to talk about them. This kind of presentation is common at scientific and research conferences.

These brief presentations are not intended to take the place of a final product (although they may). They should, however, take some of the emphasis off the final product and give students a better sense of research as a continuous process, with presentations as part of an ongoing process.

Step 7: Identify new needs and make new plans. As stated earlier, the inquiry/investigation procedure views research as a recursive, never-ending process. Students should be encouraged to pursue problems or questions that interest them long after a unit of study is over.

> ***Some of the most successful inquiry/investigation research projects have lasted for almost an entire school year and engaged children so deeply that by the end, they had things to tell the experts!***

Teachers may even let an inquiry/investigation unit continue for months, if it is producing good learning. Some of the most successful inquiry/investigation research projects have lasted for almost an entire school year and engaged children so deeply that by the end, *they* had things to tell the experts!

Conducting an Inquiry/ Investigation Project: A Sample Scenario

To help teachers obtain an idea of how student inquiry/investigation projects work in practice, a sample scenario follows. This scenario is based on a unit theme entitled "From Mystery to Medicine" and is presented in diary form as written by the teacher.

Monday, November 21
I remember that last year the unit theme "From Mystery to Medicine" brought up many questions, and that it got the class off to a great start planning their inquiry/investigation projects. This year, though, the students haven't had as many questions about the theme, and they haven't been as thoughtful as last year's class about this subject. For instance, last year when the students read "Medicine: Past and Present," they were all interested in part of an article that discussed smallpox and cowpox. They wanted to know if diseases in animals are the same as diseases in people. They had many questions: "Do dogs catch cold?" "How did people know that cowpox was like smallpox?" "Are there families of diseases just like families of animals?" This year the only questions that have

come up are "Do you catch cowpox from cows?" and "Can you get sick from being around animals that are sick?" Well, I suppose that's a start. But then I started to think that maybe we hadn't read the article as carefully this year as last. The article is packed with ideas. You can't read it like a story. So I decided to go through the article with the class again before we started to plan our inquiries about concepts in medicine.

Tuesday, November 22

On my second reading to the class of the story "Medicine: Past and Present," I modeled noticing things I hadn't noticed before and questioning things we had let slip by in the first reading. I encouraged the students to do the same, and pretty soon they were discovering all kinds of things that made them wonder. One student remembered hearing on the news that new kinds of flu first develop in pigs and then move to humans. Did this, she wanted to know, mean that you could use the pig flu as a vaccine? That excited everybody. They acted as if they had made a discovery that could help prevent flu epidemics!

By the time we finished this second trip through the article, our Concept/Question Board was full of juicy questions to research. Last year, I made a mistake at this point. We had so many questions on the board that I thought we needed to boil them down. So we summarized all the questions into a few big ones such as, "What are the causes of disease?" and "How do medicines work?" I didn't realize then that we were replacing questions the students were really interested in with more general questions that are more like those in textbooks. Fortunately, the inquiry/investigation projects went pretty well anyway, and the interesting questions came up again.

This year, I didn't want to take any chances. We grouped the questions instead of trying to merge them. We had germ questions, medicine questions, surgery questions, animal questions, doctor questions, and, of course, miscellaneous questions. I had the students individually list their first, second, and third choice of a question group. With this information, I quickly set up five planning groups, assuring the students that the groupings were not final. We could change things as plans started to take shape.

The groups set to work planning their research and discussing who would take up particular questions. Toward the end of the 15 minutes that I allotted for this initial planning, Alexandra came to me and said, "I am the only one who would like to study birth defects. Can I study it by myself?" I hesitated. I knew Alexandra's little brother had been born with a heart defect and that she was very worried about him. I feared that studying about such things would make her more anxious, yet she clearly wanted to understand more about birth defects. So I told her to go ahead on her own and that I would be part of her research team. I knew she was a good researcher and could work on her own, but I thought some emotional support might be needed.

Wednesday, November 23

The groups presented their needs and plans today. The surgery group's questions and plans sounded so interesting that some other students wanted to abandon their groups and join the surgery group. I tried to convince them that if they worked at it, every topic could be as interesting as surgery. The germ group was not getting off to a very lively start, however. The group did have a good idea—getting a microscope so that they could look at germs—but the questions they came up with were unpromising: "What are germs?", "How big are germs?", "What makes germs?", and so on. So I tried to get the whole class to help the group think about germs.

I said, "I think maybe the discovery of germs was the most important thing that ever happened in the history of medicine. Do you agree with that?"

Some students agreed and some didn't, but they all began to realize that there was a lot about germs that they didn't understand. I also got them to think about the question "Do germs matter in surgery?" The students had no doubt about the answer to that one. Other questions developed: "Do germs have anything to do with medicines?", "Are they important for doctors?", and "How do they relate to animals?"

By the time we were through, the members of the germ group thought they had the most important topic, because all the other groups needed their information. They agreed to produce a new set of questions based on the class discussion.

I had planned to start the conjecture part of the cycle today, but the germ group obviously wasn't ready. Instead, I sent all the groups back to think about which were the most interesting and important questions related to their topics. They really went to work on that challenge. I also had them write their questions on sheets of newsprint so that they could be posted for everyone to see.

Monday, November 28

Last year, I didn't really understand the idea of *conjecture*, and I didn't handle it very well. I thought *conjecture* meant the same as "guess," so I told the groups to write out their guesses as the answers to their questions. Of course, turning the activity into a guessing game made it pointless. Furthermore, it implied that the purpose of research was to find out whether or not the guesses were correct, which I realize now was kind of silly—although the kids didn't seem to find it that way.

To avoid the "guessing game" pitfall, I led a whole-class discussion concerning the posted questions, and I asked, "Do you already have some ideas about any of these questions?" The response was slow at first, but I praised every idea as good thinking and worth following up. Pretty soon the ideas were coming thick and fast. Finally I asked, "Are there any questions that you don't have any ideas about?" As soon as one student suggested a question, another student would come forth with an idea. "Well, then," I said, "it looks like we already have answers to all the questions, so we don't need to do any research."

Of course, they didn't buy that. "Maybe our ideas are wrong. They're just theories," Alfonso said. I seized on that.

"Yes, they're theories," I said. "Some may be good, some not so good. But they can all be made better. That's what research is about. It's about improving your theories." Then I sent them off into their groups to work out their best conjectures or what I called "starting theories."

Tuesday, November 29

Today we read the selection "Sewed Up His Heart." Of course it generated a lot of interest in surgery and it set up renewed clamor from kids who wanted to shift into the surgery group. I almost gave in to it—I could imagine the whole class doing research on various aspects of surgery. But instead, I led a discussion of all the things a doctor needs to know in order to do surgery—germs, diseases, medicines—the very things that different groups were going to investigate.

Thursday, December 1

Yesterday, the groups were busy researching their questions and today, when we were discussing the story, the students had a lot of information to offer about surgery, germs, and so on. I felt they were really starting to get the idea of contributing to a common store of knowledge.

Friday, December 2

The students are finding lots of material on their own. I mentioned a TV show I had seen about new strains of germs that are resistant to antibiotics, and several students mentioned that they had also watched it. I'm encouraging them to watch the TV guides for educational shows they can use. The Internet sites we have looked at in class also have offered wonderful information.

Monday, December 5

I've been encouraging the students to put up notices on the Concept/Question Board of good material that they have found, as well as requests for help in finding particular information.

Wednesday, December 7

Alexandra has been doing excellent research on birth defects, and I arranged for her to meet with the surgery group to tell what she has learned about surgical repair of birth defects. They were so fascinated that they urged her to join their group, and I was happy that she agreed.

Monday, December 12

Today we had an informal revision session in which the groups reported on anything they had found out that would be interesting to the whole class. This was a lively session, and it produced a lot of questions to spur the groups on to more research. I then scheduled two groups each day, starting on Wednesday, to give a more organized report of their findings and to discuss any problems. Good news: Mike Jacobs, our science consultant, has agreed to come on Friday with a microscope that he assures us will let us see germs. So I've scheduled the germ group for that day.

Tuesday, December 13

Mrs. Carter, Carole's mother, visited the class today. She is a nurse and was well prepared to show the students some very useful first-aid techniques. Afterward she told me how impressed she was with the questions the students asked. "They know more about some of these things than I do," she said. "And I've studied them."

Wednesday, December 14

The first group to report—the diseases group—started by giving a rather dull recital of facts. I decided right away that I would have to change the focus or this was going to be a dreary three days. "Remember," I said, "this isn't

a test to find out what you've learned. We're all in this together. Tell us what you know that can help the rest of us with our understanding, and tell us what we can do to help you with yours." This sort of stunned them. I should have built up to it better. But Carole, who was still riding high from her mother's visit, got the idea and told us about what was still puzzling the surgery group about diseases. Because these were issues the students in the other groups had never thought about, it led to a very worthwhile exchange.

Thursday, December 15
Good sessions today with the animal group and the surgery group.

Friday, December 16
I got Mike Jacobs to agree to come early and meet first with the members of the germ group so that they could get in synch and become familiar with the microscope. For the meeting with the whole class, Mike let the germ group do much of the talking, while he handled the microscope viewing. This resulted in a very good session.

Monday, December 19
The winter break was coming soon and I realized that we were going to have to rush things to wrap up our research. I told the class that by Wednesday, the last day of classes before the break, every group had to be ready to report on how their original theories had changed as a result of their research. This brought howls of protest. The students argued that they hadn't done enough research yet, that they still needed to find out more, and that two days wasn't enough time to prepare.

I sympathized with them. I felt it was a shame to cut off the research just when they were making so much progress and learning so much. If it hadn't been for the winter break, I would have let the research go on for another week. It seemed best, however, to start fresh in the new year. I said that I wanted everyone to write two pages in their journals explaining the main problem that they had researched, what their original theory of conjecture had been, and how they had improved it through what they had learned. I emphasized that I didn't want them to summarize everything they had learned, but to focus on the most important ideas that had helped them to understand the theory.

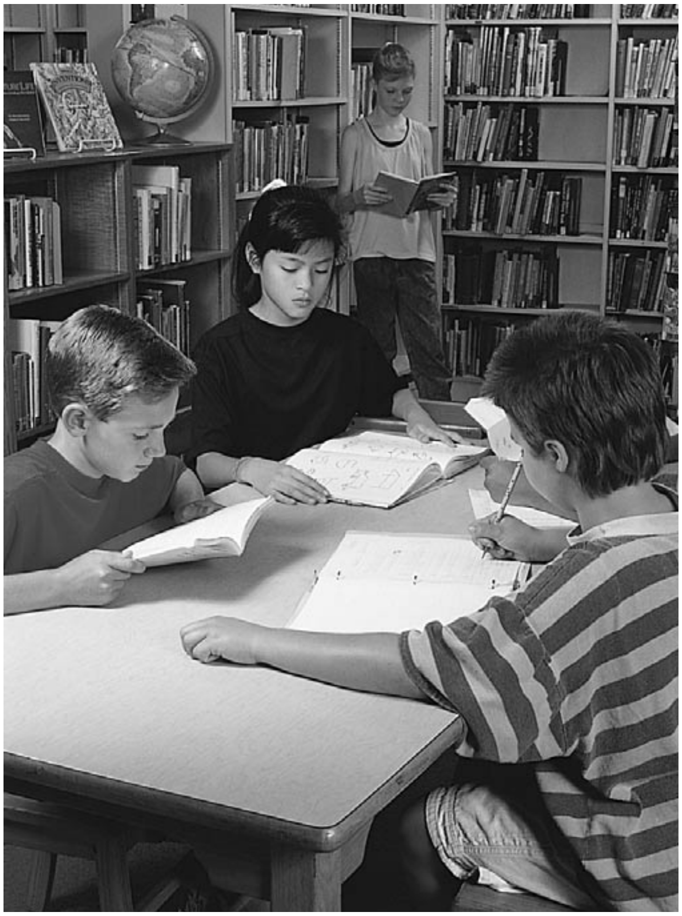
Tuesday, December 20
As the students were writing in their journals, I looked over shoulders and watched for those who were just writing down facts. More students than I had expected were doing this. Old habits die hard. I asked them to keep this question in mind, "What did you find out that really made you stop and think?" Most often, this question made them focus. With a little coaching, they got back on track, writing the "story of my theory" that I was after.

> ***... the students had helped each other, they had taken pride in each other's learning, and they continually brought new ideas to class.***

Wednesday, December 21
Instead of formal presentations, I conducted a long discussion in which I saw to it that every student had a chance to talk about his or her own theory improvement. This was the reverse of the usual report presentations, which in my experience are about 20 percent interesting and

80 percent boring to everyone, sometimes even the presenters. I think the discussion was interesting because of what had led up to it: the students had helped each other, they had taken pride in each other's learning, and they continually brought new ideas to class. Although the unit is over, it is plain to the students, and to me, that trying to understand medical science and health is still a work in progress. My work in progress is 26 journals that I'm taking home to read over the winter break. But, you know what? I'm actually looking forward to it!

> ***Students must learn how to identify problems, ask different kinds of questions, confirm understandings, predict outcomes, interpret text, wonder about meaning, and compare ideas.***



Conclusion

Learning to read empowers children. Learning to *learn* enables them to use that power intelligently to direct their own learning process and to take charge of their own lives. ***Open Court*** recognizes that for students—even kindergarten students—to become more self-directed and purposeful in their learning, they must have opportunities to learn how to make connections between their existing knowledge and the new knowledge they encounter in reading and through discussions. Students must learn how to identify problems, ask different kinds of questions, confirm understandings, predict outcomes, interpret text, wonder about meaning, and compare ideas. In brief, they must have opportunities to engage in the kind of inquiry and investigation that will prepare them for real-world thinking, decision making, and problem solving.

References

Anderson, R. C., & Pearson, P. D. (1984). A schema-theoretic view of basic processes in reading. In P. D. Pearson, R. Barr, M. L. Kamil, & P. Mosenthal (Eds.), *Handbook of reading research* (pp. 255–292). New York: Longman.

Bereiter, C., & Scardamalia, M. (1989). Intentional learning as a goal of instruction. In Resnick, L. B (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser*. Mahwah, NJ: Lawrence Erlbaum Associates.

Bereiter, C., & Scardamalia, M. (1993). *Surpassing ourselves: An inquiry into the nature and implications of expertise.* Chicago: Open Court.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (1999). *How people learn: Brain, mind, experience, and school.* Washington, DC: National Academy Press.

Brewer, W. F. (1989). The activation and acquisition of knowledge. In S. Vosniadou, & A. Ortony (Eds.), *Similarity and analogical reasoning.* New York: Cambridge University Press.

Brown, A. (1987). Metacognition, executive control, self-regulation, and other more mysterious mechanisms. In F. E. Weinert, & R. H. Kluwe (Eds.), *Metacognition, motivation, and understanding.* Hillsdale, NJ: L. Lawrence Erlbaum Associates.

Brown, A., Bransford, J., Ferrara, R., & Campione, J. (1983). Learning, remembering, and understanding. In J. Flavell, & E. Markman (Eds.), *Handbook of child psychology: Vol. 3. Cognitive Development* (4th ed.). New York: Wiley.

Brown, A., & Campione, J. (1990). Communities of learning and thinking, or a context by any other name. *Human Development, 21,* 109–125.

Bruer, J. T. (1993). The mind's journey from novice to expert. *American Educator, 17,* 6–15, 38–46.

Dewey, J. (1997) *How we think*. New York: Houghton-Mifflin College.

Giere, R. (1991). *Understanding scientific reasoning* (3rd ed.). Fort Worth, TX: Harcourt Brace.

Lehrer, A., & Chazan, D. (1998). *New directions for teaching and learning geometry*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Matthews, M. (1994). *Science teaching: The role of history and philosophy of science.* New York: Routledge & Kegan Paul.

Palincsar, A. S., & Brown, A. L. (1984). Reciprocal teaching of comprehension—fostering and monitoring activities. *Cognition & Instruction, 1,* 117–175.

Popper, K. (1992). *Conjectures and refutations.* London: Routledge & Kegan Paul.

Schack, G. D. (April, 1993). Involving students in authentic research. *Educational Leadership,* 29–31.

Vosniadou, S. (1991a). Children's naïve models and the comprehension of expository text. In M. Carretero, M. Pope, R. J. Simons, & J. I. Pozo (Eds.), *Learning and instruction: European research in an international context* (Vol. 3, pp. 325–336). Oxford: Pergamon Press.

Vosniadou, S. (1991b). Designing curricula for conceptual restructuring: Lessons from the study of knowledge acquisition in astronomy. *Journal of Curriculum Studies, 23*, 219–237.

White, B. Y., & Frederickson, J. R. (1998). Inquiry, modeling, and metacognition: Making science accessible to all students. *Cognition & Instruction, 16*, 13–17.