Workshop, Grades K-1

Research Through Inquiry and Investigation

Sometimes, adults read simply to enjoy a gripping novel, a good story, or a beautifully crafted poem. Often, though, adults read to gain specific knowledge, to find information on a range of topics, from tax laws to lawn mower repair, from who won the local high school basketball championship to who won the Nobel Prize for Medicine. The ability to use reading as a tool for finding information, feeding interests, answering questions, and solving problems is a hallmark of scholarship. But the tools and processes of scholarship need not serve only adult scholars. The inquiry/exploration procedure adapts these tools for young students, providing them with the skills to develop questions and theories, seek answers, and integrate the knowledge they gain along the way.

Inquiry in ***Open Court Reading*** and ***SRA Imagine It!*** allows and encourages students to find out about things that really matter to them. It is a process that can take place in other curricular areas, especially Science and Social Studies, but often so much content needs to be covered in these areas that there is not enough time. Subjects like Science and Social Studies can and often are worked into the inquiry process in ***Open Court Reading*** and ***SRA Imagine It!***.

How Does the Inquiry Procedure Differ from Conventional Research Instruction?

In conventional elementary school classrooms, students generally conduct what is called research by collecting information and then using that information to prepare a final paper. Their research procedure 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.

Selecting a topic usually involves choosing from a list of topics suggested and provided by the teacher. Students then locate and read encyclopedia entries or articles in a library or on the Internet, taking notes as they read (Schack, 1993). Although this procedure may result in the preparation of an adequate paper, there is little meaning to be gained from such a static and formulaic process. Indeed, it may give students a distorted and diminished idea of what real research is all about.

Ample evidence exists that elementary school students can do ambitious, self-guided, historical, and experimental research that seeks to answer real questions or to solve real problems (Schack, 1993). The inquiry/exploration routine is based on the assumption that students can do research that will help them construct (and help them learn to construct) a deeper base of knowledge and understanding.

The routine presents research as a never-ending, recursive, and dynamic cycle. Like professional researchers, students produce their own questions and identify their own problems, develop their own ideas or conjectures about why something is the way it is, and then pursue the answers. As is sometimes the case with professional researchers, students may not find the answers they seek. What they will find are more questions. Structuring the questions, developing conjectures, pursuing the answers, revising ideas, and setting off on new avenues of research and exploration are the foundations upon which deep knowledge and expertise are based. The web of knowledge expands, deviates, and travels in unpredictable and often very exciting ways.

While preserving and celebrating the open-ended character of real research, unexpected findings, and new questions, the inquiry/exploration routine provides sufficient structure so students do not get lost or bogged down as they explore new concepts. To do this, the procedure follows these important principles (Bereiter & Scardamalia, 1993):

- Research focuses on specific problems, rather than on general topics.
- Conjectures, predictions, and ideas guide the research.
- New information is gathered to test and revise conjectures.

- Dynamic discussion, frequent and ongoing feedback, and constructive criticism are important in all phases of the research, but especially in revising problems and conjectures and assessing research plans and needs.
- The inquiry/exploration process is cyclical and, thus, essentially endless. Each new set of findings produces new problems and conjectures, which lead, in turn, to new cycles of research.

Theoretical and Research Foundations of the Inquiry Routine

The inquiry/exploration routine is based on analyses of how real-world research proceeds, the theoretical foundations of which can be found in the work of John Dewey (1997) and Karl Popper (1992). Dewey emphasizes the importance of integrating experience, interaction, and reflection into the research process, and he argues that learning by doing is more productive than learning by rote or dogmatic instruction. Popper further supports the procedure with his theory that knowledge grows 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 tested, and those that do not satisfy needs and goals are rejected.

The procedure is equally grounded in studies of cognitive science, the study of how humans think and learn. Cognitive science-based teaching methods have been called "the educational equivalents of the polio vaccine and penicillin" (Bruer, 1993). Evidence from case studies, such as the following, demonstrate the inquiry/exploration procedure's results:

- Sixth grade students learned conceptual physics more successfully than eleventh and twelfth graders who were taught by conventional means (White & Frederickson, 1998).
- Second-grade students learned to represent geometrical forms, surpassing college undergraduates' work (Lehrer & Chazan, 1998).
- Remedial students raised their reading comprehension scores by four grade levels in just twenty days of instruction (Bruer, 1993).

The following are elements of cognitive science research that are evident in and pertinent to the inquiry/exploration procedure:

Expert-novice comparisons

Experts are those people, in a given field, who have extensive and complex subject-area knowledge, and they organize and present that knowledge in ways that reflect a deep understanding of their subject. They are able to retrieve important aspects of their knowledge flexibly, with little conscious effort. In contrast, novices often lack conscious awareness of their mental processes and may also lack strategies for carrying out demanding mental and intellectual tasks (Bereiter & Scardamalia, 1993; Bransford, Brown, & Cocking, 1999). An expert, for example, might notice patterns and trends in the information he or she gathers that a novice might not see. Expert-novice comparisons examine what experts in a particular field know and do that novices in the same field do differently or not at all (Bereiter & Scardamalia, 1989). These findings are valuable pedagogical tools and can serve as models for successful learning methods.

Metacognition

One primary distinction between experts and novices is that novices lack a conscious awareness of the knowledge they already possess and of themselves as problem solvers. They lack the strategies to monitor, structure, and control their own thinking; they do not function at a level of metacognition (Brown, 1987; Brown, Bransford, Ferrara, & Campione, 1983; Giere, 1991).

Almost by definition, students are universal novices, constantly faced with new learning tasks and processes. Instruction, then, should help students to be intelligent novices. Though they do not possess expert knowledge of a particular subject, intelligent novices know how to seek that knowledge, how to find it. They learn how to learn, using texts as tools (Brown & Campione, 1990).

Schema theory

Schema theory is grounded in the idea that a student's system of understanding, or knowledge structure, is often more important than the facts he or she may or may not know (Anderson & Pearson, 1984). According to schema theory, knowledge (or schema) is a huge network of abstract mental structures that represent, compose, categorize, and arrange our understanding of the world.

As expert-novice comparisons have underscored, learning depends to a large extent on a learner's prior knowledge and experience (Anderson & Pearson, 1984; Brewer, 1989; Vosniadou, 1991b). Each of us has many schemata (plural), and relationships among and between our schemata are like webs, with each schema interconnected to many others. Networks of schemata grow and evolve as we acquire new information and skills and as we integrate them with the knowledge and strategies we already have.

Naïve theories

Students are constantly applying their own theories to concepts, whether or not they have any previous knowledge of or familiarity with the concepts in question. These personal theories, 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 they view as experts) tell them (Vosniadou, 1991a, 1991b).

Because they have already developed naïve theories of particular concepts, students may find experts' explanations of these concepts confusing. As a result, they will often distort an expert's explanation in order to integrate and align it with their own naïve theory. Some students may also compartmentalize ideas and information: they may use the expert theory at school but stick to their own theory for life outside of school (Vosniadou, 1991a, 1991b).

Young students, for example, may come up with dramatic misconceptions about concepts such as the shape of the Earth or the size of the planets, even after teachers and other adult experts provide them with scientific explanations (Vosniadou, 1991b). Instruction, then, must anticipate and be prepared for these misconceptions and theories. Though naïve theories are not correct, they are often rational, and must be identified and addressed directly as such before they can be replaced with accurate concepts and information.

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, taking into account each student's ability to negotiate new tasks and information. As the novices become more competent and familiar with the exercise, the expert calls on them to participate at increasingly challenging levels (Palincsar & Brown, 1984).

Joint cognitive process model

When a group of people work together in a unified process towards collectively agreed upon goals, they are employing the joint cognitive process model (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 might work 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 exploration. All members of the community are actively involved in a reflective, social process that brings multiple perspectives both to the analysis and evaluation of their work processes and to the products of their shared exploration (White & Frederickson, 1988).

What Does Inquiry Look Like in the Classroom?

In the classroom, the inquiry/exploration procedure takes students through a recursive cycle that involves many steps:

- Decide on a problem or question to research.
- Formulate an idea or conjecture about the problem.
- Identify needs and make plans.
- Reevaluate the problem or question based on what has been learned.
- Revise the idea or conjecture.
- Make a presentation.
- Identify new needs and make new plans.

Students may go through these steps several times before they come to the end of their research. In more advanced, professional research, the cycle can go on for years, or even a lifetime.

The ***Inquiry Journals*** and Unit Investigation Management charts and Research Rubrics in the ***Open Court Reading ©2002/2005 Teacher's Editions*** provide support throughout the procedure. If you are using ***SRA Imagine It!***, the tools provided online in eInquiry provide support throughout the inquiry process. The***Inquiry Journals*** provide a place for students to record what they learn from the selections they are reading, outline their research, record findings, keep track of assignments and schedules, note reactions, and learn new study and research skills. It is a chronicle of their research, providing a clear picture to them and the teacher how they are progressing as researchers through the year. Each inquiry lesson includes a Unit Investigation Management chart. This chart helps the teacher see what the students have done in previous lessons, what they are expected to do in the current lesson, and what they will do in upcoming lessons in the unit. Research Rubrics, found in the Assessment Overview for each lesson in the ***Teacher's Editions*** in grades 2-6, are a tool for assessing the students' understanding of the phases of the research cycle. A record sheet is provided in the back of the ***Inquiry Journal Annotated Teacher's Edition*** to keep track of students' progress.

Decide on a problem or question to research. Real research is motivated by a problem or a question, not just a general interest in or curiosity about a topic. When the procedure is first introduced, students may need help 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 similarly broad topics. It is easy to find information about broad topics, take notes that paraphrase the text, categorize the information, and then write a paper in encyclopedia-entry form. If students are urged to formulate a question or problem rather than a topic, they might come up with something like: "What is a meteor?" But this is merely a broad topic followed by a question mark.

In the inquiry/exploration 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 trying to develop a research problem about astronomy are likely to produce standard questions, such as "How were the planets formed?" or "Will we be able to travel to other planets?" which are questions the reference sources are likely to have answered directly. With the answers right before them, students may be tempted to paraphrase what the sources say, and to limit their line of inquiry to those topics and questions addressed in reference texts.

Though the questions mentioned above may genuinely be of interest to students, without the reference texts as prompts, students tend to come up with very different questions, and they are often more challenging and interesting questions to research. For example, students might come up with an astronomy-related question such as "Why are planets round?", a question for which they will not easily find a direct answer. Rather, 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 their own explanation of why planets are round. And as their explanations begin to form, they will advance their research, asking new questions and following new lines of inquiry; perhaps they will even conduct experiments on spinning and roundness.

Having students generate problems or questions before consulting sources has the additional advantages of bringing their early 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 the 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 as such. However, when students are encouraged to investigate their own questions, they take responsibility for thinking through problems; they will work to find a scientific understanding of what gravity is and to bring their own conjectures in line with this information. They will find that gravity is not a substance; indeed, it is not an identifiable thing at all (and they may be pleased to learn that this problem bothered Isaac Newton as much as it bothers them).

Choosing the right kind of introduction to use, and deciding whether or not an introduction is needed at all, depends as much on the students as on the concept being presented. In some classes, students will already have information and ideas relevant to the concept. If this is the case, they should start right in on discussion and developing questions and problems. It does not matter if their information and ideas are spotty or inaccurate. What does matter is that students have enough accurate information to begin thinking.

But if students who are exploring astronomy have no notion of the cosmos, 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. A videotape, a story, a movie, or an account of personal experiences may provide the basis of the introduction. For reasons given already, however, no matter what medium or form the introduction takes, it should not be an encyclopedic overview of the concept.

Occasionally, students may select a problem and then complain that it is too hard for them. "Too hard" may mean that students cannot find definitive answers to their questions; however, by this definition, most real research questions are too hard. When this occurs, teachers should remind students that the criterion of success is not finding definitive answers, but making progress and developing an understanding. 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 young scholars.

Formulate an idea or conjecture about the problem. How can students judge their progress as they research a problem? Because students presumably do not know the answer to the questions they are researching, their progress cannot be assessed by how close they are to the answer. A better indicator of progress might be, for example, a student's ability to 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." Conjectures—both initial conjectures and revised conjectures—play a central role in inquiry/exploration research. In fact, *the purpose of research is to improve upon and modify initial conjectures*. Students sometimes resist making their initial conjectures, arguing that they do not know enough about a concept to make good ones. The point to emphasize is that the goal of the research is to improve conjectures, and all researchers must begin with a conjecture to improve upon. You can respond to a student's resistance by encouraging him or her to simply make the best conjecture he or she can. Remind students that if they can already locate a weakness in their initial conjecture, that weakness can be a good problem to begin researching. By identifying weaknesses and fallacies in their conjectures, students can begin to progress and improve upon them. Why is the term *conjecture* used? Why not use a simple, more familiar word, such as *theory, idea, hypothesis, belief*, or *opinion*? Everyday language, though familiar and comfortable, often falls short of offering adequate alternatives to technical vocabulary. *Idea* is a broad term, which lacks the specificity of a conjecture. A student can entertain a conjecture without holding that conjecture as a personal *belief* or *opinion*; so those terms do not work. The term *theory*implies something more elaborate and formal than a conjecture. And though*hypothesis* is the most closely related term for the conjecture concept, a *hypothesis*must be well-grounded, based on evidence or preliminary research. Inquiry/exploration procedure does not demand or expect that students' initial conjectures will be well-grounded.

Conjecture, though it may seem a difficult word and certainly one that will be foreign to young students, is a very precise term in the context of the inquiry/exploration procedure. When a term is to be used as frequently as *conjecture* is used in inquiry/exploration research, it is important that the word used be exact and precise. One way to think about how *conjecture* relates to more familiar terms is this: The inquiry/exploration procedure begins with a conjecture, but as research continues and conjectures change, develop, and evolve, these conjectures may become hypotheses and theories.

Identify needs and make plans. At this step, students identify and make plans to identify the resources, collect the information, and develop the strategies and group responsibilities they will need in order to address their conjectures.

To identify needs and make plans, younger students might be encouraged to discuss questions that are related to the problem they will research. These discussions will alert younger students to a wider and more complex range of relevant information on the subject, keeping them from getting bogged down or limited by one key word or idea. Older students, however, should begin by asking themselves what they need to know and what they want to learn; teachers can facilitate this process.

For example, in one case study, an older 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, more specific question: "How does the heart work?" Although this is a researchable problem, it's one that's directly addressed in many reference books; students may be tempted to paraphrase from the books rather than engage in the research process. When the student was asked to identify his knowledge and information needs, however, he produced the following problems: "Why does the blood have to circulate? Why can't it stay in one place?" These questions are fundamental to developing an understanding of the circulatory system and give a meaningful scientific direction to research that might otherwise have been entirely descriptive.

Reevaluate the problem or question based on what has been learned. In 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, the information he or she finds may come in many different forms: print materials, videos, sound recordings, electronically stored data, experiments, observations, or interviews and consultations with experts. This is an exciting part of the research procedure; but it can easily become distracting and cause students to lose sight of their original problem or conjecture.

A frequent reevaluation of research steps and processes helps students keep the information search true to its original purpose. Using the new information they obtain to change their conjectures or reformulate their problems is, perhaps, the step that takes the most time and effort throughout the inquiry/exploration research cycle. But for this step to be effective and useful, 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 also a challenging part since it is hard for students to change or reformulate ideas. This is something they usually don't do.

When students examine their findings, they must be prepared to identify what they have learned that is new, to respond to the questions, "What does this tell us that we didn't know before?" or "How does this information help us?" Students should not think of these questions as criticisms of their original conjectures or bases of knowledge, but as legitimate queries; questioning and revising one's original conjectures and ideas are the primary goals of the research process. 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.

Revise the idea or conjecture. In research, 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 and will vary from project to project. New facts, new insights, or new inferences may be a basis for revisions of various kinds. Knowledge does not come simply from the acquisition of new information, but from using new information to reconsider beliefs and conjectures.

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? The amount of variability inherent in the revision process can make it difficult for teachers to provide much structure for revisions. This phase is largely discussion-based: individual students, research teams, and the class as a whole must have opportunities to meet and consider possible revisions prior to making them. These discussions are where most of the real thinking and knowledge building will occur. The teaching principles to apply will be the same as those you would use to make any discussion successful: constructive commenting, refocusing, seeding, and participant modeling. Possible questions for teachers to ask include: Based on what you've found out, what do you still need to know? What is not clear?

The success of the revision-step discussions will depend on how well the cycle of research is progressing in general. If students are pursuing interesting and interrelated problems and are finding 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 discussions are static and students are not presenting new information or generating new ideas, it may be too early to have a productive discussion about revisions; students should continue to work on the research stages that precede revisions.

Those students whose research is going well will be eager for an opportunity to report what they have found out, but may not be so eager to hear the findings of others. A reasonable strategy is to let the most eager students report briefly and then refocus the discussion on assessing their reports. For example: "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?"

Make a presentation. In the inquiry/exploration research cycle, presentations are an offshoot of the revision step. And because revision steps are expected to occur frequently, ample opportunities arise for presentations of all kinds—written or oral report, videotape, demonstration, model, or poster. Presentations play an important role in the professional research world as well, and often research findings are presented in phases, as more research is still being conducted and findings are still being analyzed. These presentations are similar to the ones students will give—informal presentations to colleagues, talk-show appearances, seminars or conferences, and posting papers on the Web.

These presentations all contribute to the revisions process: feedback and criticism from peers may change the course of the research or lead the researcher to modify the conjecture. They are occasions for the presenters to think through what they have done, what conclusions they have drawn, and what the implications of those conclusions are or might be. By the time research is formally presented or published, it has been shaped by several presentations. Most of these valuable steps are lost in the conventional approach most schools call "research," where presentation occurs solely as the final step of research, as the conclusion to a thinking and learning process rather than as a repeated step within that process.

The following is a list of suggested informal presentation formats. Each is intended to take less than ten minutes, including several minutes devoted to questions and discussion. (Students may find it interesting that at real-world research conferences, researchers are commonly 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 the class reactions.
- **Video/computer highlights**. A research group presents and comments on short (one-minute or less) segments of a videotape, PowerPoint® or Web site display that group members think will be of value or interest to other research groups.
- **Book or article highlights**. This format is similar to the video/computer highlights, with the presenters reading excerpts aloud and offering comments.

- **Preliminary findings**. A group uses graphs and other visuals to help communicate its findings.
- **Presenting problems**. Students who have found puzzling or inconsistent information present their problem and seek suggestions from the class.
- **Poster session**. If there is not enough class time available for all groups to present their research, teachers can allot a certain amount of wall space for each presenter to put up a display pertaining to his or her group's work, such as graphs, pictures with captions, or summaries in large print. At the start of a poster session, each presenter may have one minute to announce the intent of the poster. Then students are free to walk around and study the posters, with the presenters standing by to engage viewers in discussion. This kind of presentation is common at scientific and research conferences.

These brief presentations will not necessarily 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 playing a regular and productive role.

Identify new needs and make new plans. In the inquiry/exploration procedure, research is 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. If dynamic productive learning continues, teachers may even let an inquiry/exploration unit continue for months. Some of the most successful inquiry/exploration research projects have lasted for almost an entire school year and engaged children so deeply that by the end, they had information and ideas for the experts!

Conclusion

Learning to read empowers students, but learning to learn enables them to use that power intelligently to direct their own learning process and their own lives.***Open Court Reading*** and ***SRA Imagine It!*** recognize 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 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. They must have opportunities to engage in the kind of inquiry and exploration that will prepare them for real-world thinking, decision making, and problem solving.