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Pathways to Inquiry

INVITATION TO INQUIRY

In *Inquire Within* (Llewellyn, 2007), I familiarized readers with several means of inviting students to inquiry-based learning through the Invitation to Inquiry Grid (see Figure 1.1). The invitations are like pathways teachers regularly use to initiate student inquiries. They include (a) demonstrated inquiries and discrepant events, (b) structured inquiries, (c) guided inquiries (also called teacher-initiated inquiries or problem-solving activities), and (d) self-directed inquiries (also called student-initiated or full inquiries). For each approach, the source of the question, the procedure, and the results differ, originating from either the teacher or the student. Whereas demonstrated inquiries and discrepant events are more teacher led, the source of the question and the procedure stems from the teacher. Self-directed and student-initiated inquiries, however, are more student led. Here, the source of the question and the procedure originates from the student. Thus, as one moves from left to right on the grid, the ownership of the question and the procedure shifts from the teacher to the student.

	Demonstrated Inquiry or Discrepant Event	**Structured Inquiry**	**Guided Inquiry or Teacher-Initiated Inquiry**	**Self-Directed Inquiry or Student-Initiated Inquiry**
Posing the question	Teacher	Teacher	Teacher	Student
Planning the procedure	Teacher	Teacher	Student	Student
Analyzing the results	Teacher	Student	Student	Student

Figure 1.1 Invitation to Inquiry

Source: Llewellyn, D. (2007). *Inquire Within: Implementing Inquiry-Based Science Standards in Grades 3–8*, 2nd ed. Thousand Oaks, CA: Corwin.

As we move from left to right on the grid, we also notice how the level of ownership varies. The left side of the grid appears to be more structured and more teacher centered, whereas the right side is less structured and more student centered. Figure 1.2 illustrates the level and significance of ownership. And as any teachers will assert, when students own their question, they engender a feeling of empowerment. We'll address the notion of structure and ownership later in Chapters 4 and 5.

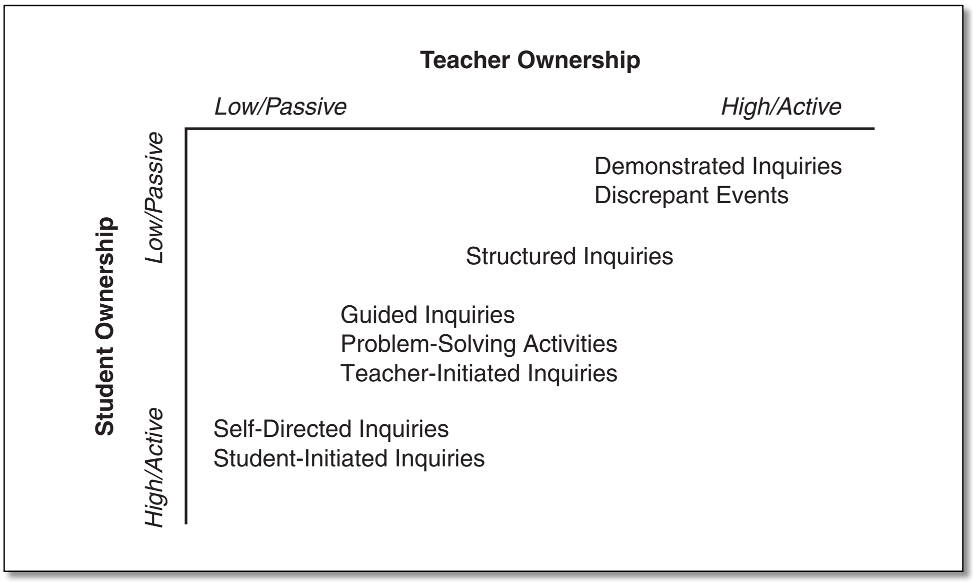

Figure 1.2 Student-Teacher Ownership

As teachers chart their yearlong instructional plans, they take into account the prior experience their students have in scientific inquiry, noting some students may come to class with little or no prior experience, while others possess a wealth of previous experiences in posing their own questions, formulating their own procedures, and collecting and organizing their own results. Experienced inquiry teachers take this into consideration when planning just how and when to introduce inquiry-based opportunities into their courses. For some classes, it may necessitate a gradual transition from left to right on the grid—spending several months on demonstrated inquiry and having students perform structured or guided inquiry activities before moving on to more open-ended investigations. This, of course, is a very natural scaffolding process in learning science through inquiry. For other students more experienced and savvy in self-guided explorations, the shift from left to right occurs more quickly. Thus, each class marks its own progress toward inquiry-based learning.

CATEGORIES OF SCIENCE INQUIRY

Throughout the literature and in professional conversations among elementary, middle, and high school teachers, the terms *discrepant events*, *structured inquiries, guided inquiries,* and *self-directed* (or open or full) *inquiries* are frequently used. To avoid any confusion, let's describe each of these categories of inquiry.

A *demonstrated inquiry* or discrepant event is a teacher-led presentation focusing on a particular topic or phenomenon geared toward capturing students' attention. What makes them different from traditional demonstrations is that a discrepant event often culminates in an attention-grabbing observation that is counterintuitive to the students' normal understandings. These types of presentation are often thought of as mind-engaging introductions to a new topic that peak interests and challenge prior conceptions. The unexpected results are usually contradictory to students' normal experiences and serve to promote curiosity and motivation for the concept about to be studied. Demonstrated inquiries also serve as a springboard into further questions and follow-up inquiries.

In *structured inquiry,* students engage in a hands-on activity or lab, collect and organize data, and draw conclusions but follow a precise set or sequence of instructions and procedures provided by the teacher or the textbook. In *The Lingo of Learning,* Colburn (2003) describes a structured inquiry as a situation where "the teacher gives students a hands-on problem they are to investigate, and the methods and materials to use for the investigation, but not expected outcomes. Students are to discover a relationship and generalize from the data collected" (p. 20). Despite the negative connotation, structured activities are often mislabeled as cookbook labs, confirmation labs, or verification labs. The distinction between structured inquiries and cookbook labs is that with structured inquiries, the student assumes more responsibility for determining how to collect and organize his or her data, whereas cookbook labs usually provide the student with directions regarding what data to collect and how to collect the data, along with a predetermined chart or table that shows how to fill in the data. I contend that if a student cannot design a data table for an inquiry, he or she probably doesn't completely understand the investigation or the variables being tested. Therefore, one of the foremost ways to modify a traditional cookbook lab into a structured inquiry is to remove the data table and encourage the students to design their own. This simple step will give students more opportunities to analyze and comprehend their results.

A second distinction is that with structured labs, although the procedure is provided, students are responsible for discovering the evidence to support the stated hypothesis (if there is one) and looking for patterns and relationships within the data. Cookbook labs usually suggest the patterns through prompts and fill-in-the-blank-type questions. They are best for compliant learners who depend upon the teacher for direction and affirmation. Colburn (2003) further suggests that in structured inquiries, ". . . students are largely responsible for figuring out what the data might mean—that is, they analyze and interpret the data. . . . In a verification lab, on the other hand, all students are expected to arrive at the same conclusion—there's a definite right answer that students are supposed to be finding during the lab activity" (p. 20). Keep in mind that analyzing evidence and formulating an explanation are essential reasoning skills strengthened through science inquiries.

Whether we call an activity a structured inquiry or a cookbook lab, teachers know that at times and within given situations, students need structure and direction in carrying out their investigations. The key for teachers is to introduce structured investigations but gradually wean students toward more independence. More about the need for structure will come in upcoming chapters.

In *guided inquiry,* the teacher poses the question or the problem to be investigated and suggests the materials to be used while the students, on their own, design and carry out a procedure for the investigation. The students then form conclusions and explanations from the data collected. In this book, guided inquiry is synonymous with problem solving or teacher-initiated inquiry, since the source of the question or problem originates from the teacher.

And last, *self-directed inquiry* is a situation where students generate their own questions concerning a topic or phenomenon and then design their investigations, identify variables, and select and carry out procedures to answer these questions. At the conclusion of the self-directed inquiry, students then propose claims and explanations supported by the evidence collected and communicate the findings to others. Self-directed inquiry accentuates creativity over conformity and helps students create structure from ambiguity.

Since it's sometimes unrealistic to expect students to generate self-directed questions without any frame of reference, these inquiries usually originate from open-ended explorations, demonstrated inquiries, and discrepant events that cause students to wonder and ask, "What would happen if . . . ?" For our discussion, self-directed inquiry is synonymous with student-initiated inquiry, full inquiry, or open inquiry.

In concluding the differences among the categories, let's return to the seven segments of scientific inquiry introduced in the Introduction. For structured inquiries, the question and the procedure portions are orchestrated by the teacher. The students will follow the prescribed directions in the procedure, collect appropriate data, and conclude the results of the investigation. For guided inquiries, the teacher provides the question to be investigated, and the students are responsible for designing and conducting the investigation as well as collecting and analyzing the data and communicating their findings to others. Last, in full inquiries, the students are responsible for all aspects of the investigation: formulating the question, planning and carrying out the procedure, and analyzing and communicating the results. Knowing this, teachers can now take any activity or lab and use the segment list to determine which category the investigation falls under.

WHAT TEACHERS AND STUDENTS DO AT EACH APPROACH TO INQUIRY

We can further our understanding of the different pathways to inquiry by identifying the behaviors demonstrated by teachers and students for each approach. Since each approach in the Inquiry Grid has its own distinctive set of performances, Figures 1.3 through 1.6 help us to distinguish one approach from another. As you read through the descriptions, notice how the responsibility subtly shifts from teacher-led demonstrated inquiries to student-led full inquiries.

Level of Inquiry	What the Teacher Does	What the Student Does
Demonstrated Inquiries and Discrepant Events	• Introduces a new concept by creating awareness and interest • Poses questions and elicits responses to assess students' understanding of the concept • Acts as a motivator by providing observable discrepancies to generate curiosity and inquisitiveness • Generates a "cognitive hook" to a new or abstract concept • Asks students to describe or explain their observations • Models appropriate scientific and safety procedures and processes • Uses "show and tell" modes of instruction	• Connects new observations to prior experiences and knowledge • Takes notes and provides a justifiable explanation to observable phenomenon • Builds and elaborates upon the observations and explanations of others • Shows curiosity and interest by asking "what if" and "how come" questions in response to the demonstration or discrepancy

Figure 1.3 What Teacher or Student Does—Demonstrated

Level of Inquiry	What the Teacher Does	What the Student Does
Structured Inquiries	• Provides step-by-step, sequential procedures to follow • Provides materials and supplies as listed on the activity sheet or lab • Assigns roles to students on a rotating basis • Acts as a coach by ensuring all students are on task and understand the procedure • Encourages students to work as a group • Asks probing questions and answers questions when appropriate • Provides follow-up and "going further" questions and inquiries	• Obtains materials and supplies as listed on the activity sheet or lab • Reads and follows directions according to activity sheet or lab • Uses science process skills to collect data • Communicates and collaborates with other group members • Makes observations, collects data, and records observations • Designs data charts and tables for organizing collected data • Looks for patterns and relationships within the data • Draws conclusions and formulates explanations • Evaluates and communicates the results • Asks new and related questions based on the data collected

Figure 1.4 What Teacher or Student Does—Structured

Level of Inquiry	What the Teacher Does	What the Student Does
Guided Inquiries, Problem-Solving Activities, and Teacher-Initiated Inquiries	• Provides a problem to solve or a question to investigate • Encourages students to design a means to solve the problem or answer the question posed • Acts as a facilitator to the problem-solving process • Makes suggestions for needed equipment and supplies • Encourages accountability and shared decision making among the group members • Poses questions and prompts to extend students' thinking • Directs students to other resources of information related to the problem • Organizes a means for students to communicate their findings and explanations • Assesses students' ability to solve problems	• Defines the nature and the parameters of the problem • Brainstorms and generates possible procedures and solutions to solve the problem • Selects and designs a strategy or plan • Creates models or illustrations of the design • Selects appropriate supplies and equipment needed • Implements the plan to solve the problem • Uses science process skills to collect and analyze information about the problem • Communicates and collaborates with other group members • Makes observations, collects data, and records observations • Designs data charts and tables for organizing collected data • Looks for patterns and relationships within the data • Draws conclusions and formulates explanations • Evaluates and communicates the results • Asks new and related questions based on the data collected

Figure 1.5 What Teacher or Student Does—Guided

Level of Inquiry	What the Teacher Does	What the Student Does
Self-Directed Inquiries and Student-Initiated Inquiries	• Provides an open-ended exploration to initiate questions • Acts as a mentor to assist students to uncover answers and solutions to their questions and problems • Assists in providing needed equipment and supplies	• Makes initial observations and speculations that drive personal questions • Acts as an investigator by stating a question • Takes ownership of the question • Brainstorms and identifies variables related to the question

Level of Inquiry	What the Teacher Does	What the Student Does
	• Poses additional questions and prompts to apply and elaborate students' initial questions • Directs students to other resources of information related to the question or problem • Organizes a means for students to communicate their findings and explanations • Assesses students' ability as self-directed learners	• Constructs a claim, hypothesis, or prediction to test • Designs procedures to answer the question • Determines equipment and supplies needed • Carries out the procedure to acquire data and evidence • Designs data charts and tables for organizing collected data • Organizes the data in the form of a chart or table • Looks for patterns and relationships within the data • Describes the relationship among variables • Determines the validity of the data and evidence • Supports or refuses the claim based on the evidence collected • Draws conclusions and formulates explanations • Evaluates and communicates the results • Asks new and related questions based on the data collected

Figure 1.6 What Teacher or Student Does—Self-Directed

TEACHER POSITIONS AT EACH APPROACH TO INQUIRY

Associated with the observable behaviors of the teacher, we can also describe the physical position the teacher assumes in relation to the students in the room for each approach to inquiry. Figure 1.7 shows the stance the teacher takes for each approach.

During a demonstrated inquiry, the teacher plays the role as a *motivator* and usually assumes a "front-and-center" location so he or she can be easily seen by all the students in the class. Although the teacher may certainly move about during the presentation, the students' attention is centered on the teacher and focused on the demonstration table, usually located at the front of the classroom. In this approach, students are most often seated in typical rows and columns.

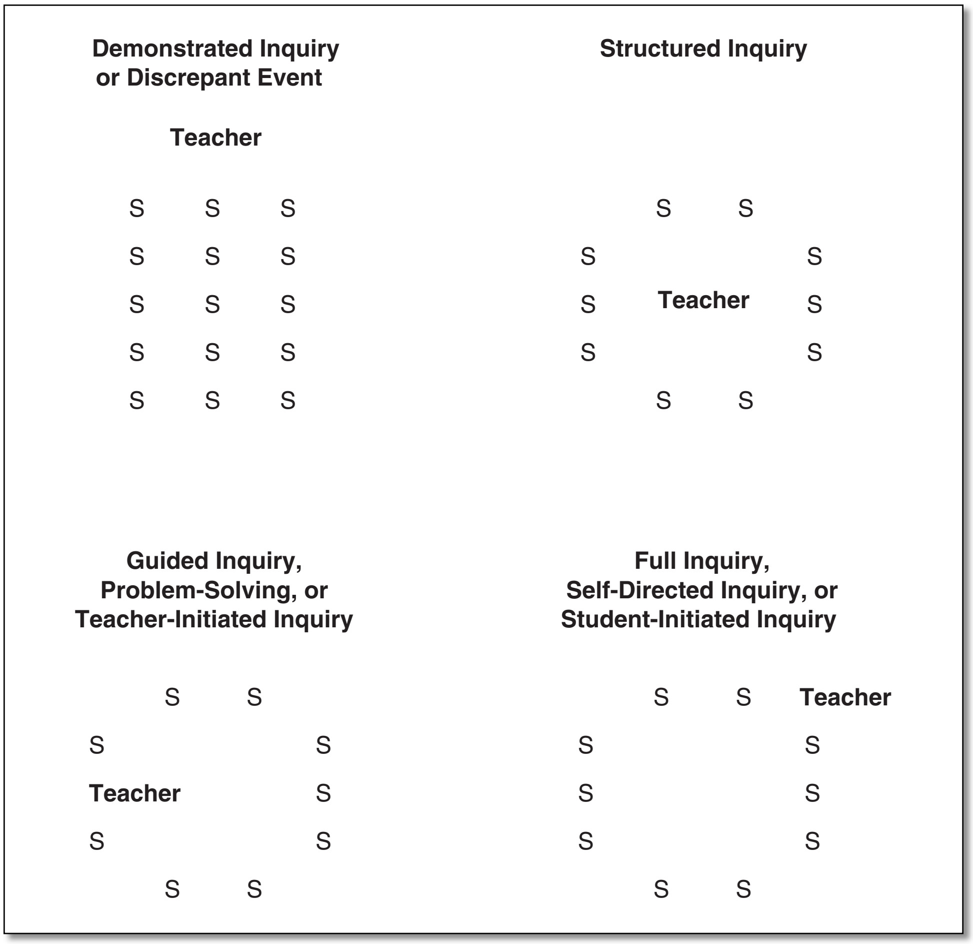

Figure 1.7 Teacher Positions

During a structured inquiry, the teacher assumes the role as a *coach* and takes a position of "calling the directions" of the activity and having the students "play out" the procedure in small groups. The teacher maintains a central focus, but in this case, moves from group to group, assisting and clarifying the directions to students and critiquing their data and results.

During a guided inquiry, problem solving, or teacher-initiated inquiry approach, the teacher takes a less centered position and assumes the role of a *facilitator* or peer investigator—standing alongside the student groups. Similar to the structured activity, the teacher moves around to the individual groups providing guidance when asked but offers a less directed response to student queries. Here, the teacher may provide prompts and probing questions to help students decipher the question or problem being posed and suggests subtle responses that direct students to formulate their own procedures and explanations.

Finally, during a full or self-directed inquiry, the teacher takes on the role of a *mentor* without blatantly and overtly trying to influence the direction of the student or the small groups. In contrast to the "sage on the stage" during demonstrated inquiries, the teacher plays the role of the "guide on the side" in full inquiries. What this means is that as the teacher moves from direct instruction to inquiry-based instruction, she is astutely aware of her changing role and relationship with her students. Furthermore, as she moves from a dispenser of information to a catalyst for exploration and discovery, she becomes conscious of her physical stance within the classroom environment and understands how the shift in proximity to the students determines her style of interaction within the classroom.

ADVANTAGES AND BENEFITS TO EACH APPROACH

There are several reasons teachers choose to demonstrate discrepant events, provide structured inquiries, give guided inquiries, or propose student-directed investigations. Each has its own advantage and benefit in an educator's instructional toolbox.

Demonstrated Inquiries and Discrepant Events

Besides being engaging and often entertaining, teachers choose to perform this approach when the following are present:

- The presentation results in a counterintuitive discrepancy from the observer's normal experience or acts as a cognitive hook to "wow" students and engage them in the upcoming topic.
- The presentation demonstrates specific skills and techniques for making observations and collecting data.
- The teacher wants all the students focused on a particular, controlled situation.
- Time, equipment, and/or supplies are limited.
- The content or topic is focused on a specific observable event or phenomenon.
- Toxic, flammable, or dangerous chemicals or materials are being used.
- An explosion may occur, and safety is an issue.
- The teacher needs to model a particular procedure.
- The procedure is complicated for students to follow.

Structured Inquiries

Likewise, teachers choose to perform structured, step-by-step inquiries or prescribed labs when the following are present:

- Students lack prior experience in self-directed learning.
- Specific skills and techniques for making observations and collecting data need to be followed.
- Time, equipment, and/or supplies are limited.
- The question and the results are predicated on a specific procedure to follow.
- Safety is an issue.

- Students need to follow a sequential procedure to obtain desired results.
- Students need to practice following directions.

Guided or Teacher-Initiated Inquiries

At the next level, teachers choose to give students guided or teacher-initiated inquiries, sometimes called problem-solving activities, when the following are present:

- The question or problem is focused, but there are many creative ways to answer the question or solve the problem.
- Teachers plan to give students choice and flexibility in solving problems.
- They guide students in how to map various ways to solve problems.
- They would like students to model the problem-solving process and appreciate and understand the ways scientists solve real-world problems.
- They want students to develop scientific reasoning skills in designing their own ways to collect, organize, and explain the results of their research.
- They want to emphasize attributes in decision making as well as habits of mind like creativity, imagination, persistence, and thoughtfulness.

Self-Directed or Open-Ended Inquiries

And finally, teachers choose to give students self-directed inquiries when the following are present:

- They want to give students choice and flexibility in posing their own questions and designing ways to answer those questions.
- They desire to have students model the process of inquiry and appreciate and understand the ways working scientists conduct investigations.
- They want students to design their own ways to collect, organize, and explain the results of their research.
- They want students to use scientific reasoning skills to explain the results of their investigation.
- And as in problem-solving situations, teachers want to emphasize attributes in decision making as well as habits of mind like creativity, diligence, innovation, and reflection.

Now that you have been introduced to the teacher behaviors and positions for each approach, go back to Figure 1.2 and compare the ownership modes to the behaviors (Figures 1.3–1.6) and positional stances (Figure 1.7) the teacher plays for inquiry approach. In doing this, you will embark on internalizing and articulating your involvement for each level of instruction.

You may also choose to take some time at this point to reflect on how often during the instructional year you presently spend on providing traditional demonstrations, discrepant events, cookbook or verification labs, structured inquiries, guided inquiries, and student-directed inquiries. Do you provide many more traditional demonstrations than labs and investigations? If so, what classroom conditions and restraints cause you to do this? How often do you plan for student-led explorations? Over the course of the entire school year, what's your present percentage of instructional time spent on traditional demonstrations, discrepant events, cookbook or verification labs, structured inquiries, guided inquiries, and student-directed inquiries? What would you like the distribution to look like a year from now? Three years from now? These questions should provoke you to reflect on your instructional delivery and plan the types of professional development you need to move from your present to your desired state of teaching.

WRITING QUESTIONS FOR REFLECTION AND DISCUSSION

At the end of a chapter in many professional development books, the author provides questions for further discussion. Contrary to this and to model good inquiry, the questions should come from *you*. So whether you are reading this book alone, collaborating in a small study group, or participating in a college course or summer institute, write three questions you have. The questions may be about the challenge you face in implementing science inquiry in your school or a reaction to a section you read in Chapter 1. This exercise is designed to evoke thoughts, opinions, viewpoints, and, most of all, personal feelings about what you are reading. After you write your three questions, share them with others also reading this book. Set a few moments aside, maybe over coffee or pizza, to answer each question. Your questions, responses, and reflections will become beneficial as you progress on your journey into DSI.

Three questions I have include the following:

1.

2.

3.