A blueprint for cultivating inquiry

by Julia Gooding and Bill Metz

Scientific inquiry, a methodology that can trace its roots back to the time and teachings of Socrates, has been an elusive and evolving part of our educational lexicon for many years. The Socratic approach to teaching, in its simplest form, can be thought of as instruction that involves the use of open-ended questions and investigative queries of students rather than a teacher-centered, lecture format. For some reason, however, this straightforward idea has been difficult to translate into practice. Perhaps this is because the definition has become more sophisticated.

In 1996 the National Research Council (NRC) challenged all educators with its release of the National Science Education Standards (NSES) when it described inquiry as, "A multifaceted activity that involves making observations; posing questions; examining books and other sources . . . planning investigations; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results" (p. 23). The Exploratorium for Inquiry (2004) corroborated this definition by proposing that inquiry involves students raising their own questions and then planning, designing, and conducting their own investigations. But how does a teacher create this student-centered environment in the traditional classroom? What strategies are essential for the development of what the NSES refer to in Standard B as pedagogical content knowledge?

Perhaps one way to gain a deeper understanding of inquiry is to discuss what it is not. Inquiry is not a singular fix such as adopting a standardized set of procedures or teacher responses; it is not a specific set of activities or process skills or following the scientific method; it is not implementing a commercially developed or homegrown curriculum; and it is certainly not the alluring "glitz of kits."

Inquiry embraces all of these components. It is an amalgam of the foregoing, a synergy, and as such is much more than the sum of its parts. To compound matters, the selection of these components is generally not under the direct control of the practitioners. One notable exception is the manner by which teachers respond to student input.

It is our contention that teachers who cultivate scientific inquiry as suggested by the NSES are actually practicing the art, rather than the act, of teaching. Concordantly, Hammerman (2006) asserts, "Inquiry is the art of investigating questions, critiquing potential alternative answers. Science as inquiry, then, is a social and thoughtful activity requiring much more than the practice of skills or the completion of a set of steps leading to the 'right answer'" (p. xxiii).

The autonomous manner by which teachers might better elicit responses from students will be the primary focus for the remainder of this article. It should be noted that while these teacher behaviors are not new, they are at the heart of inquiry teaching since they fall under the direct control of the teacher.

The blueprint

Just as architects design blueprints that are the plans for a building, curriculum developers design lessons that are plans for teaching a concept. Similarly, just as the skills and techniques of the builders determine how close a building is to the essence of the plan, the skills and techniques of the teachers determine how close the lesson is to the essence of the plan. Therefore, regardless of who designs a lesson, it is the teacher who turns the act of teaching into the art of inquiry.

Figure 1 identifies Seven Simple Strategies (Gooding 2007), which were adapted from Reynolds, Abraham, and Nelson (1971); Rowe (1974); and Campbell, Campbell, and Dickinson (1996), and are critical response techniques for teachers to use when encouraging student participation and critical thinking, thus cultivating inquiry.

Calling for Clarification

Calling for Clarification is an overriding tactic because it requires students to revisit or rehearse their answers—to rephrase and expand their thinking. This strategy should be used even if the student's answer is right on target. Sousa (1995) contends that learners ask two questions about entering information, "Does this make sense?" and "Does this have meaning?" (p. 16). The *sense* part reflects the learner's attempt to fit the new information into existing schema, while the *meaning* issue describes the relevance for the learner. In trying to make sense of new information, students sometimes create inappropriate connections or misinterpret incoming information all together and misconceptions can occur. Furthermore, one should, "Seek first to understand, then to be understood" (Covey 1989, p. 255). Educators should heed these words because "getting inside" students' heads to find out how they are processing is a fundamental component of formative assessment and provides guideposts for crafting more accurate paths of instruction. The importance of this technique cannot be overstated as a means of compelling students to dig deeper into the meaning of their responses, bringing sense and clarity to their thoughts. This strategy also provides time for students to process information and time for teachers to formatively assess student understanding. Teachers can initiate this strategy by using phrases such as: How else might you say that? Is there anything you could add to make that more understandable? Could you rephrase that?

Calling for Evidence

The linchpin of scientific literacy is interpreting and/or reporting the results of investigations with supportive data. Calling for Evidence necessitates that students explain their results or conclusions through the use of evidence in the form of numerical results, a list of observations, artifacts, or even documentation from a variety of sources. There are many ways to solve a problem in science and the solutions can be as varied as the students in the classroom. The problem-solving techniques used by each student may be different, but this diversity of thinking is beneficial for enhancing the problem-solving repertoire of each student (Gooding and Metz 2006). It should be emphasized that while there are many ways to resolve an issue, there is only one appropriate way to report it, and that is with the use of evidence. To do this, a teacher may ask: How do you know that? What is your proof? What data did you find that would help you explain your decision? What do you think your data show? Can you use your data to make up a rule to describe your results?

FIGURE 1 **Critical response strategies for developing inquiry**

- Calling for Clarification
- Calling for Evidence
- Calling for Evaluation
- Wait Time I
- Wait Time II
- Playing the Devil's Advocate
- Not Looking for the "Right" Answer

Calling for Evaluation

Once students have collected and processed data, Calling for Evaluation is a way to raise the bar by requiring them to use higher-order thinking skills (HOTS), which became popular with the publication of Bloom's taxonomy in 1956. This strategy requires students to go beyond the processing of data to the crafting of reasonable speculations. Initiating queries might be: What else do you think could have caused that? If you did this investigation again, what would you do differently? Why would you do that? Why do you consider your answer reasonable? How could you change this investigation? How do you think you could make the investigation better? Why would it be better?

Wait Times I and II

We can all thank Mary Budd Rowe (1974) for bringing the concept of Wait Time to light (the lag time between the teacher's question and the student's response or the teachers' repetition/rephrasing of the question). This strategy is incredibly simplistic in that the teacher asks a question and then remains quiet while students process and respond. Research into Wait Time indicates that this simple technique increases the number of student responses, the length and complexity of student answers, and generates more student-to-student interaction (Stahl 1991). The optimal wait time for a given question should be adjusted to its cognitive level. This well-established approach is absolutely essential for inquiry, as well as its companion tactic Wait Time II, the time between a student's response and the introduction of another question or a direction by the teacher. By remaining silent and noncommittal following a student's response, the teacher can enable the student to extend and clarify his or her answer, not through a specific request, but merely by remaining quiet. If the maxim, "He who does the talking does the learning," is a reasonable assertion, then Wait Time is indispensable.

Playing the Devil's Advocate

This technique is one that resembles the verbal exchanges that occur in a courtroom. Students are invited to defend their data-based decisions against differing points of view and to propose alternative interpretations for the conclusions drawn by others. These varying opinions could originate with the teacher but, over time, it is anticipated that evaluating through peer review would become the joint responsibility of the teacher and students. Playing the Devil's Advocate helps prepare students to consider the ideas of others rather than accepting or rejecting them out of hand. This is an important skill in establishing a healthy sense of skepticism about proposals, positions, data, and data interpretations. In a global sense, the necessity for training students to play this role also includes interpreting the controversial issues associated with the benefits and consequences of human actions on the environment.

Not Looking for the "Right" Answer

As noted earlier, there are many ways to go about solving a problem but it can only be reported using evidence. When teachers seek a pre-determined response to a question that could be answered in a variety of ways, they do so at the exclusion of a number of other creative and plausible responses. Likewise, if students believe there is only one acceptable response, they do so at the exclusion of a number of creative and plausible responses. In either case, discussion is stilted and perhaps focused long before its time. Teachers need to encourage diversity of thought supported by a reasonable justification.

Conclusion

The use of appropriate question and response strategies is just as important as the design and implementation of the lessons. The previously described strategies cultivate *minds on* inquiry, which is just as significant as *hands on* inquiry, if not more so. "Learning is maximized in classes where questions are encouraged, elaboration and explanation are expected, and feedback is frequent" (Krueger and Sutton 2005, p. 18). Caram and Davis (2005) concur that by using questioning, "teachers assess students' knowledge, determine needs for focused re-teaching, and encourage students to think at higher cognitive levels" (p. 20). It is imperative for teachers to further understand that the questioning strategies described herein, much like the process skills, are not just for science. They can, and should, be used in all content areas. We maintain that that they are not only concomitant with scientific inquiry but essential for formulating data-based decisions across curricular lines and indispensable for shifting appropriate responsibilities for inquiry to the learners.

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