     

Inquiry Literacy: A Proposal for a Neologism

Bruce M. Shore, Camelia Birlean, Cheryl L. Walker, and Krista C. Ritchie, McGill University
Frank LaBanca, Western Connecticut State University
Mark W. Aulls, McGill University

ABSTRACT

Literacy definitions, the growth of inquiry literacy in science education, and the developmental nature of inquiry literacy within learners' experiences in diverse content domains are outlined. Classroom-based vignettes illustrate elements of inquiry literacy in science, social studies, and mathematics. A preliminary list of qualities of student inquiry literacy is presented. These qualities could potentially be monitored in individuals and classrooms as the range of literacy knowledge, skills, and dispositions increases in breadth, depth, and fluency.

What Is Inquiry Literacy?

Literacy. Once upon a time, literacy simply meant "the ability to read and write," the only definition still offered by the *Concise Oxford Dictionary* (1990, p. 692). Yet the idea of literacy carries considerable social weight (Scribner, 1984). Meanwhile, common language has expanded the term to, for example, computer, information, media, religious, robotics, scientific, and technological literacy. Educational Testing Service (2009) has also cited prose, document, quantitative, and health-skills literacy. We even have a subset of general literacy called functional or basic literacy. And there are others.

We are proposing that "inquiry literacy" should be added to this list because the ability to engage in inquiry, and also to communicate within and about inquiry, is critical to the 21st century, especially in, by, and for education. There are more general and more satisfying definitions of literacy. Here is one:

> Literacy is a complex set of abilities needed to understand and use the dominant symbol systems of a culture--alphabets, numbers, visual icons--for personal and community development. The nature of these abilities, and the demand for them, vary from one context to another.
>
> In a technological society, literacy extends beyond the functional skills of reading, writing, speaking and listening to include multiple literacies such as visual, media and information literacy. These new literacies focus on an individual's capacity to use and make critical judgements about the information they encounter on a daily basis.
>
> However a culture defines it, literacy touches every aspect of individual and community life. It is an essential foundation for learning through life, and must be valued as a human right. (Centre for Literacy of Quebec, n.d., Web site)

Four "commonplaces" of literacy frame any construct of literacy. It always involves a *user* who acts within a *society* to learn a *text* through a *process* (Sinclair Bell, 1993). Text, the object of the user's (student's) literate behavior, can take the form of a printed word or image. Text may also be defined more abstractly as the conceptual content that is learned. Our paper focuses on the student as the user within a society or community of educational institutions that have guiding curricula, norms, and resources. Within this society, there should be a curriculum imperative that (a) students learn the text or conceptual understanding of inquiry, (b) they learn how to engage in the inquiry process independently, and (c) they understand why it is important to develop as an inquirer in preparation for being a critical consumer of information in one's professional and personal life. The suggested process of becoming inquiry literate requires that teachers themselves first become inquiry literate and then provide opportunities for students to engage in inquiry. Students thereby learn how to ask questions, conduct investigations, gain understanding based on evidence, report their findings, and so on.

From this perspective, inquiry literacy would be the individual's capacity to critically understand and use the language, symbols, and skills of inquiry, and to reflect on their meaning and usage during and after the activity. Aulls and Shore (2008) have presented a dozen theoretical perspectives from social constructivism to critical theory, from higher education to gifted education, that support inquiry as a curricular imperative in education, and all of us and our colleagues strive to make this a daily reality. At the same time we emphasize that inquiry requires considerable personal investment to implement in teaching and learning. Although some inquiry elements can be initiated quickly (e.g., expanding student choices based on interests), it can be very challenging to go further without proper preparation, experience, and understanding of inquiry pedagogy. Depending on the level of granularity with which one examines the concept of inquiry as a set of educational and life skills, knowledge, and values, inquiry can be enacted in many ways. We shall provide some examples below.

Inquiry. The current view of inquiry is just as complex as it was during the 1990s, being perceived differently by different researchers and practitioners. For example, it is referred to as project-based science instruction (Blumenfeld, Krajcik, Marx, & Soloway, 1994; Krajcik, Blumenfeld, Marx, & Soloway, 1994; Marx et al., 1994), habits of mind (DuVall, 2001), problem solving (Helgeson, 1994), inductive teaching (Lott, 1983), discovery learning (Bruner, 1961; Wise & Okey, 1983), or the learning cycle (Lawson, 1988), to enumerate only a few.

Inquiry is learning by questioning and investigation; the questions asked and means for investigation are vast, nonlinear, and idiosyncratic. Inquiry encompasses diverse ways to study phenomena in all subject areas through dialog, asking questions, and proposing explanations based on empirical evidence (National Research Council, 1996). A requirement of inquiry is that the goal of learning activities is learning "to do" and learning "about" at the same time. Inquiry requires imaginative, evidence-based solutions achieved through critical thinking, and a deep understanding of concepts. At the most general level, Aulls and Shore (2008) identified two broad qualities of inquiry that appear to characterize all examples we have encountered in education: (a) learners' interests play a role in guiding curricular decisions--this does not preclude in any way teachers influencing these interests, and (b) shifts, or more properly, exchanges, in roles between teachers and learners--for example, responsibility for decisions about curricular choices--both content and pedagogy, evaluation roles--both formative and summative, and communication in the classroom--who speaks, to whom and when, who uses display space and for what, and the degree of communication that routinely takes place in classrooms.

It is also possible to extensively elaborate this list, including the specification of such inquiry elements as being able to exercise well-informed choices, using the language of inquiry in the discipline at hand, valuing the sharing of results of inquiry, asking good questions, designing procedures for pursuing answers to questions, evaluating the quality of evidence forthcoming in support or refutation of the answers, finding and solving problems, and working individually or collaboratively toward learning goals.

Working in the other direction, to the more general, inquiry is most often framed in a social-constructivist theoretical context (Vygotsky, 1978). Inquiry learning is about learners creating understandings in a social context. Aulls and Shore (2008) proposed a four-level model of inquiry ranging across (a) the *context* in which inquiry occurs and inquiry as a contextual variable for learning, (b) *process* or the steps that inquiry involves and the implied growth of inquiry knowledge, skills, and dispositions, (c) the *content* in two senses, what is learned through inquiry (e.g., teaching geography) and inquiry as content (e.g., how to do inquiry), and (d) *strategy*, the specific components of engaging in inquiry identified as knowledge (e.g., knowing what constitutes evidence), skill (being able to design and conduct a scientific experiment or make sense of primary sources in social sciences), and dispositions (a curious mind, valuing the sharing of results or collaboration). Inquiry can and should be associated with any subject-matter domain, either as a means to an end or as an outcome. It is, in large measure, part of what Keating (1990) called domain-general knowledge in contrast to domain-specific knowledge, although inquiry does have domain-specific qualities depending on the context.

Roots of inquiry instruction in science classrooms. Inquiry as we know it in education received its most visible impetus in science education (Aulls & Shore, 2008; National Research Council, 1996, 2000; Shore, Aulls, & Delcourt, 2008), but it is not exclusive to science, as we shall illustrate later. The idea of levels of development of inquiry or inquiry literacy (although the latter term has not been used) has been explored several times. Some of the language of science has remained attached to inquiry, but other prominent subject associations (e.g., National Council for the Social Studies, 1994; National Council of Teachers of Mathematics, 1989) have adopted inquiry as the core pedagogy and a desired outcome. It is also at the heart of just about every contemporary curricular reform in the United States, Canada, Europe, Australia, and New Zealand.

Becoming an inquirer does not happen overnight or easily, and inquiry can look different at different stages. For example, early in the process one might observe the exercise of choices that are presented by a teacher. Students wait and are hesitant to make choices because they suspect the teacher has preferences. At a later stage, students arrive in the classroom or other teaching setting and get right to work in groups of various sizes on topics that they may have initiated in mutual agreement with the teacher; direct teaching might be occasional at most. In our work with teachers in schools, we regularly encounter teachers who describe themselves as feeling the need to remain in control out of a positive sense of professional accountability. Initial steps toward an inquiry orientation to teaching and learning need to be very small for teachers as well as students, but should not stop with these small steps in order to promote the development of independent, self-directed inquirers. When we look at a student, class, or school and ask if this is an inquiry student, class, or school, we are asking about the level of inquiry literacy. Therefore, building capacity for inquiry as a fundamental pedagogical teaching and learning strategy takes time and effort as teachers and students develop the necessary literacies, skills, knowledge, and dispositions.

Schwab (1962) was the pioneer within the science community to acknowledge different levels of inquiry instruction that target three different levels of openness and permissiveness in laboratory inquiry, increasing gradually their degree of difficulty as they progress from the first to the last level. At the simplest level, the students are provided with the problems and ways by which they can discover relations or can conduct their inquiry. At the second level, students are again given the problems while the methods of investigations and the answers are left open. At the third level, however, the problem, methods, and answers are left open and students are confronted with raw phenomena.

Furtak (2006) and Bybee (2006) envisioned inquiry as a continuum of different science-teaching methods. At one end is traditional or direct instruction in which students are passive recipients of information. At the opposite end are open-ended student-centered activities in which students design and conduct investigations of phenomena of interest (Aulls & Shore, 2008). The latter is the canonical vision of scientific inquiry. In reality, depending on the perceived curricular needs of a program, science instruction usually takes place somewhere between these extremes and is itself more aligned with an integrated view of instruction put forward by the National Research Council (2006), in a form of guided scientific inquiry in which students are guided towards particular answers usually known by the teachers. This approach to instruction combines the scientific and constructivist rationale with the scientifically accepted facts and principles emphasized more recently by science-education reforms (Magnusson & Palincsar, 1995). These describe instructional design as combining various types of teaching (e.g., laboratory, lecturing, discussions) in which neither direct instruction nor unguided inquiry are exclusive approaches, and it is supposed to enhance students' knowledge of the discipline, interest in science, and their scientific reasoning skills (Bybee, 2006).

More recently, Windschitl (2002, 2003, 2004) discussed the concept of inquiry continua using the framework of inquiry levels proposed initially by Schwab (1962) and restated later by other researchers (Germann, Haskins, & Auls, 1996;

Herron, 1971; Martin-Hansen, 2002; Tafoya, Sunal, & Knecht, 1980; Zion et al., 2004). Inquiry as practiced in science classrooms is indexed on a continuum by the degree of independence students have in both posing the question, generating the problem and conducting the investigation, or providing the methods and answer to their questions or problems. There are four levels included within this continuum that gradually increase their degree of openness to students' independence in inquiry. The continuum starts with *confirmation of experiences* or *cookbook labs* as the lowest level of inquiry, in which students simply verify known scientific principles by following a given procedure. Commonly, science laboratories are used less as activities for practical inquiry-skill acquisition (Fensham, 1981; Finn, Maxwell, & Calver, 2002) and more as activities in which students perform these demonstrations in their roles of technician rather than inquirers (Bell, Blair, Crawford, & Lederman, 2003). The next level is *structured inquiry* in which the students are provided with both the problem and the procedure of investigation to complete the inquiry. The third level is *guided inquiry* through which students are given the problem to investigate but the methods for resolving the problem are left open to the students. Fourth is *open* or *independent inquiry* in which students generate their own questions and design their own investigations. There are clear similarities between Schwab's (1962) levels and Windschitl's (2002) continuum of inquiry. These levels, models, or types of inquiry can be summarized as follows. In the first model, the teacher is the authority for both the content and direction of inquiry. In the second model, the teacher still controls the content, yet provides students some opportunity to participate in the decision-making process of inquiry. In the third model, the teacher maintains control over the content, but the teacher and students collaborate about the process. The fourth model emphasizes the collaborative processes between the teacher and the students for both content and process of inquiry.

Examples of Inquiry and Inquiry Literacy in Different Domains

Although inquiry has been more conventionally identified in science, it exists across domains and will look different depending on the classroom. Often there are observable indicators that signal when the process of inquiry is occurring in the classroom. For example, Ash and Kluger-Bell (2000) provided a comprehensive reference guide to identify when students are engaged in inquiry, when teachers are engaged in inquiry and also, what an inquiry classroom environment might look like. For example, a common indicator signaling that a teacher is engaging his or her students in inquiry involves the use of open-ended questions in order to encourage further observation or investigation. Although these indicators took root in science, many can be modified for broader application to other domains, particularly observable indicators of inquiry classroom environments (e.g., students are comfortable when interacting with the teacher and other students).

Here are some vignettes, derived from real classroom experiences, that highlight instances of inquiry literacy.

Science education. Emma (all names are pseudonyms) was a self-motivated student who entered an Applied Science Research Class with a great deal of enthusiasm. She was a unique high school student because, before this inquiry-oriented science research class was offered, she found her own inquiry opportunities through special projects in her civics class and through an arts magnet school that she attended for a few years. Because she knew how time-intensive a self-directed project is, she quit the arts school for the year so that she could focus on the project she would do in her science-research class. This was the first indicator that she was inquiry-literate--she had an understanding of how much time and commitment was required to be responsible for an independent project, and she took the steps necessary to make room in her schedule.

Emma hit the ground running through the problem-finding phase because she identified a problem space in a community of practice that was meaningful to her (on-line gaming, a domain in which interactive competition places extreme demands on computer processors). She knew that it was important for her project to have an impact on an audience that extended beyond the walls of her high school. This was a second indicator of her level of inquiry literacy--she knew that authenticity was an important aspect of the inquiry process.

She had defined and framed a meaningful question for study--focused on developing a novel, efficient cooling system for the excess heat generated from computer processors--and began to pursue it with vigor. As she conducted her project, she encountered obstacles. She quickly recognized that she needed to modify her research plan to adjust for the limitations of the materials she was using to generate data. Emma was not committed to only one predetermined method for solving the problem. As a third indicator of inquiry literacy, she recognized that problem solving was not a step-by-step process, but rather required an idiosyncratic, nonlinear, adaptive, and flexible use and understanding of inquiry.

Emma's ability to identify the time required, the value of applicability to an authentic audience, and flexible use of problem-solving techniques, indicated that she did more than just engage in the inquiry process that was supported and facilitated by her teacher. She also demonstrated an understanding and awareness of how and why inquiry is a meaningful process. This metacognitive knowledge is part of inquiry literacy.

Social studies. Fred and Gina were 14-year-olds who met during a summer school program devoted to guiding the students through a research project. Both students were delighted to have independence and the resources needed (e.g., teachers who knew how to mentor independent work and time) to direct their own learning with peers who shared their level of curiosity. To enter the program, the students needed to have completed an assignment that began to narrow the focus of their interests for their independent projects. In the introductory exercise during which students introduced themselves, Fred and Gina realized that they both wanted to work on the relationship between personal decisions about urban-community involvement (e.g., volunteering, making green space, recycling, mode of transportation) and the decision-making processes of local businesses regarding the same issues, and how these issues influence marketing and employee and owner behavior.

They quickly realized that, although they had shared interests, they did not have the same ideas about the operationalization of the project. Did they want to focus on one or two issues or did they want to survey a large range of the factors that affect urban communities? How many people should they approach? Should they interview or give questionnaires? What should the questionnaire look like? Although challenging and sometimes stressful, this experience made them both aware of how problems are ill-defined and of the multiple approaches that could be used to solve the same problem.

Gina and Fred often contradicted each other during the process of doing research, when trying to resolve questions such as: How do we explain this? How do we plan the specifics of our study? Who exactly is our audience? How can we divide the work? What work do we need to do this week? With the support of their mentor, Gina and Fred managed to figure out what question to ask themselves next during this open-ended process, and came to agreement on the answers to their questions. Through the shared project, they had an opportunity to socially construct their inquiry literacy. Communication was imperative to ensure that they both contributed and were both satisfied with their summer project. Their ability to play devil's advocate with each other tested the soundness of their reasoning and taught them about the importance of reflection when making decisions during the inquiry process. Their realization of the importance of questioning each other and their ability to defend their ideas based on evidence was a sign of inquiry literacy. For both Fred and Gina, the discussions about their project made the inquiry process explicit and resulted in a socially constructed sense of inquiry literacy--for example, knowing that there is more than one possible solution path and more than one possible solution, realizing the importance of questioning and of providing rationale and evidence for decisions made, and understanding the importance of communication and the role of a mentor in the inquiry process.

An example from mathematics. Thirty-some students were in their third year of high school. They were, as a whole, rather good at mathematics, but that judgment was based on arithmetic computation accuracy and the ability to do simple word problems on their own. Many regarded mathematics as their favorite subject. Their expectation, however, based on years of experience, was that the teacher would introduce each new topic, do an example or two on the board or screen, ask if there were any questions (there rarely were any beyond requests for repetition), ask students to do half the practice examples in class while the teacher walked around and offered hints, then assign the rest for homework, due at the next class. Their first surprise came in the first minutes of the first class. The textbooks were not yet available. Everyone expected free time while a monitor was sent to the stock room to collect the books. To their surprise, the teacher sketched three signal flags attached to a rope on a pole on the blackboard, told the class it was a mast on a sailing ship, and asked, "How many messages could the crew send with these three flags?" After a moment of silence the teacher said to discuss it. The teacher then interrupted the conversations, asked for answers, and asked how each responder came to the answer reported. Additional questions were posed to the students: Suppose the crew is allowed to flip one or more of the flags upside down; now how many messages? After another dialog the students were asked to suppose they did not have to use all three flags. How many messages with one, two, or three flags? Four flags? How can you change the question to make it more interesting? The homework was to assign a code for each flag, sketch some flags to send a message, and see the next day if the messages could be understood. The importance of knowing the assumptions made by the sender became very important. This exercise was followed by a more formal introduction to permutations and combinations, and the computation was easy because everyone understood the idea behind the arithmetic, using only a limited amount of formal knowledge. The class also learned that mathematics is the language of patterns, and that there is not always exactly one right answer to every question--the answer depends on the assumptions made. On they went to number theory and a deeper understanding of why one must know the assumed assumptions before testing a hypothesis.

The teacher did not rush to distribute the textbooks. The class was actively discussing mathematics and the topics of the year before the formal vocabulary was introduced. Several elements of inquiry literacy grew in those first few days. The students grew in their ability to ask each other questions as a part of the learning process. With that came the disposition to do so; the teacher had let go some control, but still set the direction and the theme. The students quickly grasped that learning mathematics was part of a process of being able to communicate with others. Their inquiry literacy included a recognition that at a certain point they needed to look at the generalizability of their ideas. They questioned the evidence behind claims for how many messages could be delivered. They looked for patterns in predicting how many messages could be sent with different numbers of flags and different assumptions about order, direction, duplication, and multiple use. They learned to avoid simplistic explanations and to request to be able to explore a problem before being told how to do it. This combination of subject knowledge, motivational dispositions, and intellectual skills could be readily tracked as growth of inquiry literacy as well as mathematical learning as these were extended to other topics.

PS: Every member but one of that moderately inner-city class graduated from university.

A Preliminary Definition of Inquiry Literacy

The goal of this overview of our current understanding of inquiry and of literacy, its roots in science inquiry, and vignettes of inquiry literacy in action, was to propose a definition of *inquiry literacy* that is domain-general and useful for teachers and researchers alike. There does not yet appear to be a unified definition of inquiry literacy. We propose that there is a need for one, and we are proposing that it belongs in the common educational vernacular. Teachers, in particular, need to have it, value it, know how to impart it, and be able to recognize its growth in learners. Our focus is on learners, and inquiry literacy as a quality acquired by learners with help from teachers (and other adults including their parents) who are themselves, inquiry-literate.

We propose, in general, that inquiry literacy refers to an individual's knowledge of, skill with, and valuing of inquiry. Over time and with experience, these increase in breadth, depth, and fluency.

Critically, *inquiry literacy* is not only about what the students do, but also that they understand the process of what it is that they are doing. It is not enough to follow the teacher's direction and be able to ask a question, gather evidence, and come to a conclusion. The student who is inquiry-literate understands why he or she is asking a question, how much time it takes to investigate the question, how many options there are for ways to answer a question, that the evidence must be linked to the question in a meaningful way to generate conclusions, and that inquiry activities are an opportunity to take initiatives, be creative, and gain independence.

The process of inquiry is fairly well explicated by this point, and teachers who are inquiry-literate can guide students through both the challenges and rewards of the inquiry process. A student cannot be expected to intuitively know how to be an inquirer. With explicit explanation from teachers, parents, and more knowledgeable peers, as well as practical experience, students will begin to understand why they do what they do in inquiry settings. When they gain this level of understanding of the process of inquiry, they are inquiry literate. When they have become inquiry literate, their teachers can have faith that they will be able to apply the inquiry-process independently, in school, life, and work. With an inquiry-literate population, we will have a creative workforce with the skills, knowledge, and dispositions needed to find creative solutions to today's environmental, economic, and political challenges.

Inquiry literacy results in students being able to take ownership of their learning, to find inspiration and learning opportunities in unique places, and to be able to pursue their curiosities without complete dependency on an educator. This empowerment gives the gift of resiliency. When students understand why they are engaging in inquiry, and how idiosyncratic the process is, they will not become discouraged when they hit a dead-end or do not find the results they expected. They will realize that there is more than one way to approach a question and this inquiry literacy will allow them to pursue other approaches to reach their goal. Inquiry literacy is not only about what students do, but also that they understand and value the process.

Conclusion

Here, in three categories, are the salient elements that we propose form the essential details of student inquiry literacy. We expect that experimental, case-study, and theoretical follow-up will shape this list, delete or add items. We have omitted "solve problems" and "positive work ethic" because these are not unique to inquiry, and the points below include more specific qualities of what it means to find and solve problems. This proposal opens a conversation rather than closes it. These, along with inquiry outcomes we are also identifying, might have the potential to form a basis for eventually evaluating the growth of inquiry literacy at the individual and institutional levels.

Student knowledge essential to inquiry.

- The inquiry process can commence with a small amount of formal information
- Students need language, symbols, and skills of inquiry appropriate to their level (e.g., age and experience) and in context
- Their own interests and strengths are relevant and help guide curricular decisions
- Inquiry has many forms that vary in the degree of autonomy
- Inquiry is goal-driven; the goals should be clear, shared, and simultaneously include learning "to do" and "about"
- Exchanges occur in classroom roles between teachers and learners
- Inquiry requires an idiosyncratic, nonlinear, adaptive, and flexible use and understanding of the process.
- Inquiry literacy grows over time in the breadth or quantity of knowledge or skills or dispositions, their depth, and the fluency with which they are invoked.

Student skills essential to inquiry.

- Use the language of inquiry correctly in context
- Read regularly, broadly, and for a purpose when researching an inquiry topic
- Identify or select an area of interest
- Generate or find problems
- Take initiatives, intervene, co-own knowledge
- Use dialog to learn: Listen, discuss respectfully, communicate clearly
- Engage in the inquiry process independently and collaboratively
- Manage time effectively
- Assess the relevance and authenticity of a proposed problem or topic
- Ask relevant and nontrivial questions, for oneself and an appropriate audience
- Develop an appropriate approach to a problem and conducting investigations

- Collaborate with, seek advice from, and use adult or peer mentors effectively
- Develop specialized or deep understanding of concepts and content associated with the inquiry topic
- Evaluate necessity and sufficiency of resources (material, expertise, time, relevance, authenticity, etc.) to make an investigation worthy of investment at this time
- Locate, document, and organize relevant information, data, and evidence for interpretation by self and others
- Evaluate or question evidence according to source and content
- Use formal logical and analytical skills
- Monitor and evaluate progress toward solutions, adjust plans as needed (metacognition)
- Propose explanations and build understanding based on empirical evidence
- Determine the assumptions that underlie alternative answers to questions
- Evaluate solutions
- Assess the generalizability of their ideas to larger questions and others' interests
- Communicate results in writing and orally

Dispositions (on entry or acquired) essential to student inquiry.

- Be curious
- Value and pursue personal growth (breadth, depth, and fluency) as inquirers
- Positively value collaboration
- Look for patterns and links across knowledge
- Use imagination, creativity, and critical thinking
- Be comfortable with problems being ill-defined
- Be reflective about why they are engaged even if not fully succeeding
- Be comfortable with the existence of multiple approaches to solve the same problem
- Positively value sharing the results of inquiry

Closing point. In a study nearing conclusion, student teachers who experienced inquiry in more than one context or subject during their secondary or earlier school years, had a more complete understanding of what inquiry means and how to implement it. In another new study (Leung, 2009), extensive experience is required before students express high self-efficacy in inquiry; indeed self-efficacy drops with small and moderate amounts of experience. Inquiry challenges teachers and students. Inquiry literacy benefits from each instance in which it is nurtured, but the greatest gain requires a team effort within schools to ensure it happens across the curriculum and years, for maximum impact on students' inquiry literacy.

References

Ash, D., & Kluger-Bell, B. (2000). Identifying inquiry in the K-5 classroom. *Foundations. Inquiry: Thoughts, views, and strategies for the K-5 classroom* (vol. 2; pp. 79–86). Washington, DC: National Science Foundation.

Aulls, M. W., & Shore, B. M. (2008). *Inquiry in Education (vol. I): The conceptual foundations for research as a curricular imperative*. New York: Erlbaum.

Bell, R. L., Blair, L. M., Crawford, B. A., & Lederman, N. G. (2003). Just do it? Impact of science apprenticeship program on high school students' understanding of the nature of science and scientific inquiry. *Journal of Research in Science Teaching, 40*, 487–509.

Blumenfeld, P. C., Krajcik, J. S., Marx, R. W., & Soloway, E. (1994). Lessons learned: How collaboration helped middle grade science teachers learn project-based instruction. *The Elementary School Journal, 94*, 539–551.

Bruner, J. S. (1961). The act of discovery. *Harvard Educational Review, 31*, 21–32.

Bybee, R. W. (2006). Guest editorial: How inquiry could contribute to the prepared mind. *The American Biology Teacher, 68*, 454–457.

Centre for Literacy of Quebec. (n.d.). *A definition of literacy*. Retrieved May 18, 2009, from http://www.centreforliteracy.qc.ca/def.htm

Concise Oxford Dictionary. (1990). Oxford, England: Clarendon Press.

DuVall, R. (2001). Inquiry in science: From curiosity to understanding. *Primary Voices K-6 10*(1), 33–36. Retrieved January 11, 2004, from Proquest database.

Educational Testing Service. (2009). *Types of literacy*. Retrieved May 19, 2009, from http://www.ets.org/portal/site/ets/menuitem.c988ba0e5dd572bada20bc47c3921509/?vgnextoid=2c8eaf5e44df4010VgnVCM10000022f95190RCRD&vgnextchannel=6773e3b5f64f4010VgnVCM10000022f95190RCRD

Fensham, P. J. (1981). Heads, hearts, and hands--future alternatives for science education. *The Australian Science Teachers Journal, 27*, 53–60. (This journal is now known as Teaching Science.)

Finn, H., Maxwell, M., & Calver, M. (2002). Why does experimentation matter in teaching ecology? *Journal of Biological Education, 36*, 158–162.

Furtak, E. M. (2006). The problem with answers: An exploration of guided scientific inquiry teaching. *Science Education, 90*, 453–467.

Germann, P. J., Haskins, S., & Auls, S. (1996). Analysis of nine high school biology laboratory manuals: Promoting scientific inquiry. *Journal of Research in Science Teaching, 33*, 475–500.

Helgeson, S. L. (1994). Research on problem solving: Middle school. In D. L. Gabel (Ed.), *Handbook of research on science teaching and learning--A project of the National Science Teachers Association*. New York: Macmillan.

Herron, M. D. (1971). The nature of scientific enquiry. *School Review, 79*, 171–212.

Keating, D. P. (1990). Charting pathways to the development of expertise. *Educational Psychologist, 25*, 243–267.

Krajcik, J. S., Blumenfeld, P. C., Marx, R. W., & Soloway, E. (1994). A collaborative model for helping middle grade science teachers learn project-based instruction. *The Elementary School Journal, 94*, 483-498. Retrieved January 15, 2008, from Education Module database. (Document ID: 5227994).

Lawson, A. E. (1988). A better way to teach biology. *American Biology Teacher, 50*, 266–278.

Leung, D. A. (2009, August). *Self-efficacy in inquiry among students in a summer enrichment program*. Paper presented at the biannual World Conference on Gifted and Talented Children, Vancouver, British Columbia, Canada.

Lott, G. W. (1983). The effect of inquiry teaching and advance organizers upon student outcomes in science education. *Journal of Research in Science Teaching, 20*, 437–451.

Magnusson, S., & Palincsar, A. (1995). Learning environments as a site of science education reform: An illustration using interdisciplinary guided inquiry. *Theory into Practice, 34*, 43–50.

Martin-Hansen, L. (2002). Defining inquiry. *The Science Teacher, 69*, 34–37.

Marx, R. W., Blumenfeld, P. C., Krajcik, J. S., Blunk, M., Crawford, B., Kelley, B., & Meyer, K. M. (1994). Enacting project-based science: Experiences of four middle grade teachers. *The Elementary School Journal, 94*, 517–538.

National Council for the Social Studies. (1994). *Curriculum standards for social studies*. Silver Spring, MD: Author.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: Author.

National Research Council. (1996). *National Science Education Standards*. Washington, DC: National Academy Press.

National Research Council. (2000). *Inquiry and the National Science Education Standards.* Washington, DC: National Academy Press.

Schwab, J. J. (1962). The teaching of science as enquiry. In J. J. Schwab & P. F. Brandwein (Eds.), *The teaching of science* (3–103). Cambridge, MA: Harvard University Press.

Scribner, S. (1984). Literacy in three metaphors. *American Journal of Education, 93*, 6–21.

Shore, B. M., Aulls, M. W., & Delcourt, M. A. B. (Eds.). (2008). *Inquiry in education (vol. II): Overcoming barriers to successful implementation*. New York: Erlbaum.

Sinclair Bell, J. (1993). Finding the commonplaces of literacy. *Curriculum Inquiry, 23*, 131–153.

Tafoya, E., Sunal, D., & Knecht, P. (1980). Assessing inquiry potential: A tool for curriculum decision makers. *School Science & Mathematics, 80*, 43–48.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. (Trans. M. Cole). Cambridge, MA: Harvard University Press. (Originally published in Russian in 1934.)

Windschitl, M. (2002). Framing constructivism in practice as negotiation of dilemmas: An analysis of the conceptual, pedagogical, cultural, and political challenges facing teachers. *Review of Educational Research, 72*, 131–175.

Windschitl, M. (2003). Inquiry projects in science teacher education: what can investigative experiences reveal about teacher thinking and eventual classroom practice? *Science Education, 89*, 112–143.

Windschitl, M. (2004). Folk theories of "inquiry": How preservice teachers reproduce the discourse and practices of an atheoretical scientific method. *Journal of Research in Science Teaching, 41*, 481–512.

Wise, K. C., & Okey, J. R. (1983). A meta-analysis of the effects of various science-teaching strategies on achievement. *Journal of Research in Science Teaching, 20*, 419–435.

Zion, M., Slezak, M., Shapira, D., Link , E., Bashan, N., Brumer, M., Orian, T., Nussinowitz, R., Court, D., Agrest, M., Mendelovici, R., & Valanides, N. (2004). Dynamic, open inquiry in biology learning. *Science Education, 88*, 728–753.

Bruce M. Shore is Professor of Educational Psychology in the Department of Educational and Counselling Psychology of the Faculty of Education at McGill University in Montreal, Quebec, Canada, where he has also served as Department Chair and Dean of Students, and Associate Director (McGill) of the multi-campus Centre for the Study of Learning and Performance. He received the 2009 recipient of both the Faculty of Education Distinguished Teaching Award and the David Thomson Award for Graduate Supervision and Teaching.

Camelia Birlean MEd, is a former teacher, preschool director, and project evaluator in interprofessional practice and education in the health sciences. She is completing her PhD in Educational Psychology, specializing in Cognition and Instruction, and is a member of the High Ability and Inquiry Research Group in the Department of Educational and Counselling Psychology at McGill University co-chaired by Dr. Bruce M. Shore, Camelia's MEd advisor and currently PhD advisor. Her research interest focuses on differences between pedagogical expertise and subject-matter expertise.

Cheryl L. Walker is currently completing her second year of the MA program in School/Applied Child Psychology at McGill University and will be starting her PhD in 2010, also in the School/Applied Child Psychology program. Her MA thesis research examines the learning preferences of gifted students to challenge the commonly held assumption that gifted individuals prefer working alone. Other research interests include the social and cognitive components related to giftedness as well as topics surrounding inquiry education.

Krista C. Ritchie is a Consulting Scientist at the I. W. Killam Children's and Women's Health Centre in Halifax, Nova Scotia, Canada. She received her PhD in Educational Psychology with a major in Applied Cognitive Science from McGill University in 2009. During her master's (supervised by Mark W. Aulls) and doctoral (supervised by Bruce M. Shore) studies, Krista enjoyed being a member of the High Ability and Inquiry Research (HAIR) Team.

Frank LaBanca EdD, is the Science Department Chair of Oxford High School, Oxford, Connecticut. Dr. LaBanca also teaches and supervises graduate research in the Instructional Leadership program at Western Connecticut State University, Danbury, Connecticut. Dr. LaBanca is a fellow of the Connecticut Academy for Education, a member of the Board of Directors for the Connecticut Science Fair, and an Executive Board member of the Connecticut Junior Science and Humanities Symposium. His research interests focus on inquiry and creativity development in high school students.

Mark W. Aulls is Professor of Educational Psychology in the Department of Educational and Counselling Psychology of the Faculty of Education at McGill University in Montreal. Earlier in his career, his research focused on reading comprehension and reading fluency. He is currently giving his attention to the effects of interaction among students and teachers on the development of students' intellectual skills in classrooms and on the development and cultivation of inquiry learning and instruction in students, teachers, and teacher-in-training.