“Polite directiveness” in science inquiry: a contradiction in terms?

John Lawrence Bencze

Abstract

“Inquiry” is a nearly ubiquitous part of recommendations for effective practice in school science worldwide. Teachers often experience difficulties, however, in engaging students in inquiry activities in which they are asked to explore physical phenomena (and energy) and, from their inquiries, derive appropriate conclusions about nature. It has long been recommended that teachers *guide* students through such inquiry activities. In Alandeom W. Oliveira’s paper, teachers are encouraged to conduct this guidance in polite ways; that is, to use polite discourse practices. A key strategy for accomplishing this was to engage teachers in a summer institute, in which they were asked to socially construct conceptions of discourse practices that might effectively engage students in science inquiry activities. For the most part, the summer institute appeared to be quite effective, particularly for a teacher highlighted in the paper who experienced great improvements in student engagement in association with her increased use of polite discourse practices. There were a number of positive aspects of this paper, not the least of which seemed to be the effectiveness of the summer institute. However, the paper raised a number of concerns — largely around the use of what I call guided “quasi-inductive” science inquiry activities. In this paper, I explore these issues in terms of four themes, namely:

J. L. Bencze (✉)

Department of Curriculum, Teaching and Learning, Room 11-238, Ontario Institute for Studies in Education, University of Toronto, 252 Bloor Street West, TORONTO, ON M5S 1V6 Canada
Email: lbencze@oise.utoronto.ca

depth of learning, intellectual independence, representing science, and professional conscription. My major contentions include that: politely guided quasi-inductive inquiry activities are highly problematic; school science inquiry activities aimed at supporting scientists' conclusions should be more deductive; and, inquiry activities should be set within the context of personal, social and environmental issues stemming from influences of societal interest groups on professional science and technology.

Keywords Inquiry • science • discovery • nature of science • intellectual independence • social & environmental contexts

There are many potential benefits but, also, various possible problems associated with engaging elementary and secondary school students in empirical science “inquiries.” For example, although there is considerable evidence that students’ reciprocal interactions between phenomena of the world and representations of them can contribute to deep learning, because teachers often feel compelled to surreptitiously guide students’ decision making during inquiries, students can be disempowered in various ways. Similarly, although there may be much to celebrate about the extent of students’ and teachers’ sharing of learning control in inquiry activities, the contexts in which these often are set can contribute to the perpetuation of stereotypical conceptions of the nature of and possible uses for professional science (and technology).

The article ““Kindergarten, can I have your eyes and ears?”: Politeness and teacher directive choices in inquiry-based science classrooms” by Alandeom W. Oliveira represents an interesting case about how educators (including researchers and teachers) sometimes interpret “inquiry,” and how such interpretations can be seen in a positive and in a negative light. At the same time, this case provides an impetus for elaborations of alternative perspectives and practices relating to school science “inquiries.”

Oliveira's article is, largely, a documentary of two elementary school teachers' discourse practices (including those associated with "politeness") as they facilitated students' science inquiry activities prior to and after each teacher's participation in a summer institute that focused on the role of classroom discourse in school science inquiries. The two teachers who were the primary focus of the paper had been teachers for different lengths of time and were facilitating inquiries by students in different grade levels. "Mrs. Nichols" was a kindergarten teacher with three years teaching experience, whereas "Mrs. Parker" was a fourth-grade teacher who had been teaching for twenty-five years. Common to science inquiry activities in many classrooms, each teacher began with a whole-class discussion about the topic to be explored, including possible questions to be answered, followed by small-group inquiry activities by students, culminating in a whole-class discussion about findings. In Mrs. Nichols' case, kindergarten students observed various cloth pieces (i.e., of burlap, corduroy, denim, etc.) in order to draw conclusions about best use(s) for each fabric. Mrs. Parker's older elementary students, meanwhile, conducted experiments with crayfish to determine the nature of their behavior in response to various stimuli (e.g., sugar as a food source). Based on very careful and detailed sociolinguistic analyses of classroom discourse, the author determined that student engagement in inquiry activities seemed to be enhanced through uses of polite discourse practices, particularly after the summer institute. Improvements were especially noteworthy in the case of Mrs. Parker, whose class had been somewhat disengaged from their inquiry lesson prior to the institute. Significant engagement in inquiry activities by her students seemed to be associated, for example, with Mrs. Parker's use of "a greater variety of politeness and indirect strategies, including the politeness markers '*thank you*' (7 times) and '*please*' (6 times), the minimizer '*just*' (17 times), positive reinforcement (7 times), requests for physical displays of listenership (6 times), and elliptical commands (9 times)." Much of this success may be attributed to the summer institute, which engaged teachers in collaboratively reviewing multimedia

(largely video-recorded) documentaries of inquiry teaching situations in order to generate common sets of understandings of the role of discourse practices in effective science inquiry teaching.

As described below, there is much to celebrate about Oliveira's claims about associations between politeness discourse strategies and elementary school student engagement in science inquiry activities. However, the paper also raises a number of concerns. These are discussed under several themes in the constructive feedback provided below, and then in the Summary and Conclusions section.

Constructive feedback

Depth of learning

That students appeared to be more engaged in inquiry activities when teachers made significant use of politeness discourse practices is quite positive. Increased engagement can, of course, engender increased learning. Oliveira seems to attribute improved engagement, in effect, to greater sharing of learning control among the teacher and students. He states, for example, that: "inquiry based teaching is commonly defined as an instructional mode wherein the science teacher relinquishes, at least partially, his/her science expert role by forfeiting interactional rights such as providing the right answers, telling students what to do, and evaluating students' ideas."

Sharing of learning control, he contends, is mediated by polite discourse practices. He does not, however, elaborate on reasons for an association between engagement in inquiry and learning improvements. Indeed, as he discusses in the latter part of the paper, there is very little data from students — data that may have shed some light on the extent and character of student learning through inquiry activities. Although there are likely several theories to explain learning benefits of deeper engagement in inquiry, a useful one

may be *knowledge duality theory*. According to Wenger (1998), for example, deep learning is more likely when learners directly participate in development and use of representations of phenomena. Learning depth occurs, perhaps, due to students' sense of ownership in the inductive (Participation → Reification) and deductive (Reification → Participation) phases of this dialectic relationship (refer to Figure 1). There is, indeed, evidence in Oliveira's paper that induction, at least, occurred when, for example, students developed graphs to represent data from their experimental tests of effects of the number of loops of wire on the magnetic strength of electromagnets they created from batteries, wire and spools. The paper did not allude to deductive acts which, if it had been mentioned, may have signaled greater depth of/engagement in learning. The paper could benefit from more detailed, in-depth, treatment of effects of increased engagement on student learning.

Figure 1. The dialectic of participation and reification

It also seems that the paper could have benefited from greater theoretical treatment of influences of polite discourse practices on student engagement in science inquiry activities. Oliveira does explore such concepts as *solidarity* (saying “we,” instead of “I” and “you”), *subjective* vs. *objective commands* (e.g., “*I want you to listen*” vs. “*you are required to listen*”), and *process* vs. *content authority* (e.g., ways in which knowledge might be constructed vs. what knowledge is to/might be constructed). However, application of cultural-historical activity theory (CHAT) (e.g., Leont’ev 1981), for instance, may shed further light on the nature of effects of politeness discourse on engagement in science inquiry activities. Politeness might be seen, for example, as an

agent (i.e., an “Instrument” in CHAT) mediating interactions between the “Subject” (e.g., teacher) and “Object” (e.g., students’ engagement in science inquiry activities). The reciprocal (perhaps *dialectic*) nature of these interactions could be explored, yielding deeper understanding of this learning system. More could be learned, as well, through consideration of other elements of an activity system — including the “Community” (e.g., other teachers) also acting on the Subject and Object.

Intellectual independence

A key claim of the paper that might be subject to further theoretical inquiry is that a major element enabling politeness to mediate teachers’ encouragement of engagement in science inquiry is students’ level of *intellectual independence* — which refers to the extent to which students can develop and evaluate knowledge claims independent of influence(s) from authority figures (Munby 1980). Oliveira explicitly mentions intellectual independence in the paper, and infuses the paper with relevant discourse — particularly through the concept of *shared authority* in teacher-student interactions during science inquiry activities. This claim, for instance, appears in the article’s abstract: “a comparative microethnographic analysis of participants’ inquiry-based classroom practices revealed that after the institute teachers demonstrated an increased ability to share authority with students by strategically making directive choices that were more polite, indirect, inclusive, involvement-focused and creative.” The ideal set by Oliveira appears to amount to a relatively equal level of sharing of authority between teacher and students. For example, early in the paper, he states: “As both teachers and students start sharing the role of science experts, a more symmetric interactional structure emerges in the classroom, and teacher-student interaction begins to resemble collaboration among peers.” On the other hand, there appears to be some *tension* in Oliveira’s commitment to shared authority in science inquiry activities. If we imagine a continuum from completely

teacher-directed, closed-ended through to completely student-directed, open-ended activities (Lock 1990), it seems clear that he claims that authority should rest somewhere in the middle. He has said little, if anything, about the possibility of highly student-directed inquiry — despite the fact that it is the *first* of four levels (of student engagement) discussed in the National Science Education Standards (NSES) (NRC 1996, p. 29). That he has omitted discourse about such student-led inquiries suggests a preference for its antithetical position; that is, one in which the teacher ultimately decides on student actions/methods and conclusions. Indeed, there is evidence for this stance in his paper:

Not only is an authority-free stance toward inquiry-based regulative discourse difficult (if not impossible) to achieve, but its educational value must be seriously questioned. Teachers need to maintain some degree of control or authority over the inquiry-based classroom discourse in order to ensure that students have productive and high-quality science learning experiences.

This statement suggests that significant control of student procedures is to be maintained in “inquiry” activities. This stance is, indeed, evident in his choice of teacher cases to hold up as appropriate science inquiry activities. He does not problematize, for example, Mrs. Nichols’ insistence that her students avoid — regardless of their requests to do so — examining drawings of chick eggs other than for the day (9) she chose to emphasize. Similarly, although Mrs. Nichols used polite discourse about it, Oliveira chose not to problematize her resistance to allow students to pursue a study of eggs containing chicken dung smears: “We don’t need to talk about those eggs. . . . I don’t wanna touch the poopie eggs” (Mrs. Nichols). On the one hand, such regulation of student actions (and, perhaps, thoughts) may be seen as a benevolent tack, as expressed by Rudduck (1986):

[T]eachers and pupils often conspire in perpetuating a false security that manifests itself in reliance on right answers and a view of the expert as one who knows, rather

than one who uses knowledge to refocus doubt. Teachers, prompted by a kindly concern for the young people they teach, often over-simplify the complexities of living and learning; they seek to protect their pupils from uncertainty by holding out intellectual safety nets. . . . In short, the classroom has not generally been an arena for the exercise of critical thinking. . . by the time they are 14, pupils have developed “a trained incapacity” for thinking independently: they have been successfully socialized into a tradition of teacher dominance and custodial attitudes. (pp. 6-8)

Nevertheless, resisting students’ requests to pursue topics or make observations not planned by the teacher can be construed as compromising students’ intellectual independence. Use of polite discourse strategies, moreover, may be an underhanded way of ensuring students’ inquiries stay “on track.” Approving use of Mrs. Nichols’ politeness in focusing students on particular observations is clear here: Student: Day eleven is bigger → Mrs. Nichols: We are not looking at day eleven; Preston: Uh: I think that the egg is getting littler, littler space, and littler space on day twelve → Mrs. Nichols: Well, **honey** [emphasis added], we are only on day 9, okay?; Mary: [gets up and touches the chart] I see that one, that’s, that egg → Mrs. Nichols: Honey, we are looking at this one right here” [likely pointing to day 9]. Such a tack seems comparable to the traditional advice that: “You catch more flies with honey than with vinegar.” The subversive nature of such control seems clear with statements like: “[T]wo of her declaratives are prefaced with the term of endearment ‘*honey*.’ Both of these discursive strategies serve a politeness function, that is, they constitute linguistic devices aimed primarily at saving students’ face by creating the impression of social proximity and interactional affection.” One wonders if “creating an *impression* of social proximity” (emphasis added) is, actually, a reified form of politeness.

There may be many reasons for educators to prioritize such control of student learning. Oliveira’s paper cites frequent use of discourse practices to promote class “discipline,” which is a common concern of teachers when learning control is ceded to

students. However, there also are indications in the paper that control of student conclusions might also be driving control of their procedures. In other words, “inquiry” here is apparently seen as closed-ended, rather than open-ended. There is very little, if any, data to indicate the nature of teacher-student discourse relating to conclusions, but Oliveira does make some statements indicating his preference for closed-ended conclusions — such as: “[T]eachers should not prioritize interacting positively with students and saving students’ face over academic accuracy and rigor.” As discussed in the Summary and Conclusions section, below, this is not an unusual stance. Furtak (2006), for example, suggests that teachers need to keep desired conclusions secret from students while guiding them — in the course of science ‘inquiry’ activities — to those conclusions.

Representing science

Oliveira states that teacher discourse is complex and can vary according to a number of curricular and instructional variables (as per Lemke 1990). The highly regulated and, perhaps, subversive kind of learning control (manifested partly as discourse practices) exhibited in Oliveira’s article about science inquiry activities may, actually, be quite necessary in the context of the type of “inquiry” documented in the paper. There are many indications in the paper that the inquiries depicted in it have a “quasi-inductive” character. These are activities that move from specific observations to general statements, but which people argue can only be theory-driven (Lawson 2005). A typical quasi-inductive inquiry in the paper was conducted by Mrs. Nichols — who asked students to brainstorm possible uses of several different squares of fabric (e.g., linen, cotton, etc.). Oliveira also alludes to a preference for quasi-inductive inquiry when he contrasts his version of “inquiry” with “some other type of learning environment such as *verification*-oriented lab activities” (emphasis added). Verification activities are *deductive*, asking

students to acquire specific empirical evidence that might verify previously taught general concepts (Lawson 2005). In Oliveira's version of inquiry, students appear to be expected to *discover* from empirical evidence particular concepts.

For many years, educators have been aware that unguided "discovery" (quasi-inductive) activities often do not enable many students to arrive at widely-accepted "canonical" knowledge claims (Welch et al. 1981). It has long since been apparent, therefore, that teachers needed to guide students to certain conclusions — if the purpose of the activity is to teach particular conclusions from the sciences. For example, prominent educators, such as Schwartz et al. (2004), appear to interpret the NSES (NRC 1996) as intending to promote guided inquiry: "Within a classroom, scientific inquiry involves student-centered projects, with students actively engaged in inquiry processes and meaning construction, *with teacher guidance*, to achieve meaningful understanding of scientifically accepted ideas targeted by the curriculum" (p. 612). There are several problems with such guidance — including for those that prioritize politeness. Some of these are discussed under the sub-sections below, with the specific focus in this sub-section on representations of science.

Significant problems associated with guided quasi-inductive inquiries, such as those depicted in Oliveira's paper, pertain to their tendency to portray professional science as idealistically unbiased and logical. More specifically, they often, perhaps misleadingly, portray science as *empiricist-inductivist* (Hodson 1998). Students are asked to make observations of specific phenomena (e.g., magnetic strength from electromagnets with different numbers of wire windings) to generate generalizations (e.g., an algorithm covering electromagnet behaviour) about such phenomena. There are, however, strong arguments that all observations are theory-limited (Hodson 1998) and, therefore, induction may be an inappropriate way to think of knowledge building in the sciences. Indeed, related to this, it is apparent that much work in the sciences is relatively dissociated from empirical work — such as Galileo's reliance on mathematical modeling

(Klassen 2006). Although such epistemological issues may or may not seem important to children's education, a particularly worrisome repercussion of encouraging students to think of science as free from presuppositions — or biases — is that their education may neglect to enlighten them about cases in which scientists' emotional, theoretical and/or socio-cultural influences may have led them to conduct research that many would consider problematic. There is considerable evidence, for example, that the profit motive that is central to many business-science partnerships has led scientists in some fields to, for example: avoid research on topics unlikely to generate a profit, compromise the reliability and validity of their methods, and withhold from the public findings that would incriminate their products (e.g., Krinsky 2003). To the extent that such indiscretions exist, it seems appropriate to demand that students in democratic societies gain more realistic insights into the nature of inquiry in fields of professional science.

Professional conscription

Guided quasi-inductive inquiries — particularly those mediated by polite discourse practices, as highlighted in Oliveira's paper — may serve as effective *conscription devices*. In other words, because friendly guidance provided by the teacher can improve students' chances of success in achieving desired outcomes, science can be perceived by them as highly logical, systematic and successful. Like an *infomercial* on television, students may then be compelled to "buy" the item thus described. Such positive experiences may encourage them to pursue careers in the sciences and/or hold fields of science and their products in high regard. Indeed, Oliveira is explicit about this intent:

By directing student groups to think scientifically (i.e., to take on the role of scientific thinkers), Mrs. Parker urged her students to go beyond procedural and mechanic aspects of scientific inquiry and to engage in cognitive activities that could potentially grant them rightful membership to a community of science experts.

This claim appears to be supported by several anecdotes from Mrs. Parker's teaching, including: "[H]ere are the things we are trying to keep the same" and "[W]e'll see if that helps the washers"; and, "[H]e needs to make the way he winds it the same," "[Y]ou want to do is so that you are consistent every time," "[Y]ou wanna see how many you can move it can move here," and "[Y]ou are going to want it in the same place too." This sort of discourse appears to align, at least to some extent, with calls for continued or enhanced emphases on education about the nature of science (NoS) and methods of science inquiry (SI) (Schwartz et al. 2004). Although it is difficult to determine from Oliveira's paper the degree to which the highlighted teachers were *explicit* in their NoS and SI instruction, that they occurred and were highlighted in the paper may be construed as positively contributing to the development of students' literacy in science — which may serve them well as future scientists or non-scientist citizens. On the other hand, we might ask questions about the ethical character of such conscription. If science is made to appear, as it apparently is through Oliveira's paper, idealistically logical, systematic, unbiased and successful (although we are given less information about success), have students been fairly attracted to and enamored by fields of science?

One area of significant concern regarding the use of politely guided quasi-inductive inquiry activities as conscription devices pertains to their contribution to socio-economic equity. Little or nothing is stated in Oliveira's paper about this, but prioritizing this sort of inquiry activity can, apparently, sort students in terms of their relative amounts of *cultural capital* — which refers to a person's "wealth" in terms of discourse practices, knowledge, skills, etc. (Bourdieu 1983). It is apparent that students who possess the greatest cultural capital are more likely to "discover" abstract ideas that are the intended conclusions of the activity — since they may *already* have concepts relating to the desired conclusions. As Wellington (1998) notes, "[quasi-inductive] practical work is still not a good tool for teaching theory — theories are about ideas, not things. Theories involve abstract ideas which cannot be *physically* illustrated" (p. 7, italics in original).

Admittedly, since it has long been known that unguided discovery discriminates against culturally poorer students (Welch et al. 1981), teachers tend to guide — sometimes in a very polite way — students through the discovery process. However, because lessons tend to be very rapid (the lessons highlighted by Oliveira lasted about 15 min), quickly moving on to other topics, culturally poorer students still tend to struggle with this kind of learning (Claxton 1991). Consequently, it may be necessary to think of politely guided quasi-inductive science inquiry activities more as sugar-coated *tests* of students' pre-existing 'gifts' than as opportunities for a deep education for all students.

Summary and conclusions

Oliveira's paper describing teachers' improved uses of polite discourse practices for facilitating students' science inquiry activities has many strengths. The summer institute that emphasized relationships between teacher discourse practices and student engagement in science inquiry activities did appear to be effective, particularly for a teacher whose use of politeness in her interactions with students appeared to be associated with their relatively low level of engagement prior to the institute. Use of multimedia case methods, featuring teacher-student interactions during inquiry activities, appeared to be particularly effective in helping teachers to socially negotiate deeper positions pertaining to discourse practices and student learning engagement. Case methods (documentaries, plus learner questions) have been used successfully in various contexts of teacher professional development (e.g., Koballa and Tippins 2000). Oliveira's discourse analysis techniques, from a sociolinguistics perspective, seemed quite effective. Although I do not have a background in such methods, it appeared to me that all of his claims were well-substantiated with relevant data.

Here I express a number of concerns about aspects of this paper. However, I believe that the inherent problem lies outside of the immediate context of the research reported in

it. My major concerns relate to what I perceive to be a significant segment of the dominant paradigm in science education. Specifically, there appear to be significant issues pertaining to empirical activities involving students, but often guided by the teacher, usually intended to help students to learn widely-accepted conclusions from many fields of science. These types of activities appear to be deeply-entrenched in educators' views of science inquiry. The NSES document in the USA (NRC 1996), which has been influential around the world, seems to perpetuate this view:

Learning science is something that students do, not something that is done to them. . . . Inquiry is central to science learning. When engaging in inquiry, students describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. They identify their assumptions, use critical and logical thinking, and consider alternative explanations. In this way, students actively develop their understanding of science by combining scientific knowledge with reasoning and thinking skills. (NRC 1996, p. 2)

As Driver (1983) in *The Pupil as Scientist?* and others noted, it is unrealistic to expect students to discover pre-determined abstractions — such as laws, theories and mechanisms of technologies — without teacher guidance. However, as pointed out in this review, guided quasi-inductive science inquiry activities appear to lead to a number of problems for students — including with regards to their: *depth of learning, intellectual independence, conceptions of the nature of science, and conscription into fields of science and respect for such fields.*

If, as I contend, there are significant problems with guided quasi-inductive science inquiry activities that are aimed at leading students to widely accepted conclusions from fields of science, then alternative approaches are necessary. It seems clear that some form of empirical interactions with abstractions (refer to the earlier discussion about knowledge duality theory) are helpful. I believe that Lawson's (2005) recommendations in this regard are excellent; that is, to place more emphasis on deductive "inquiry"

activities and technology design projects — both of which facilitate students' *application* of previously taught (in explicit ways) conclusions of fields of science. At the same time, as indicated earlier in this review, school science inquiry activities can communicate perhaps unrealistic portrayals of professional science. Accordingly, there is considerable support in the literature for integrating education about the nature of science (NoS) and expertise for science inquiry (SI) into inquiry lessons and activities.

Although there have been numerous calls for providing more realistic NoS and SI conceptions, progress has been slow. Lederman (2006), for example, notes that, “[d]espite numerous attempts, including the major curricular reform efforts of the 1960’s, to improve students’ views of the scientific endeavor, students have consistently been shown to possess inadequate understandings of several aspects of NOS and scientific inquiry” (p. 302). An aspect of NoS and SI that has not had significant attention among academic educators, teachers and others pertains to the relative position of fields of science with respect to fields of technology and, even more so, in relation to societies (and their interest groups) and environments. In an important paper on this subject, Rudolph (2005) describes a common stereotype about science that often is portrayed in schools: “[C]urrently science in schools is cast in fundamental ways as an activity set off from the public, to be received with appreciation” (p. 809). In other words, an *isolationist* view of science is promoted, one in which scientists are seen as collaborating with each other — often in very rational, systematic and unbiased ways — to generate knowledge that may or may not then be used by fields of technology, which then create inventions that may be useful to societies (Ziman 1984). Oliveira’s paper only briefly alludes to this position, when he suggests that the teachers’ efforts to engage school children in discourse practices used in the sciences might prepare them for “membership to a community of science experts” (p. 65). Given the many personal, social and environmental problems often associated with societal — particularly from members prioritizing profit-generation — influences on professional science (and technology), it

seems clear that much more emphasis needs to be placed on education about *socioscientific issues* and its counterpart, STSE (Science, Technology, Society & Environment) Education. Such contextualized treatments of science inquiry may, perhaps with increasing intensity and complexity over children's schooling, help us to overcome many of humanity's personal, social and environmental challenges.

References

- Bourdieu, P. (1983). The forms of capital. In J. G. Richardson (Ed.), *Handbook of theory and research for the sociology of education* (pp. 241-258). New York: Greenwood Press.
- Claxton, G. (1991). *Educating the inquiring mind: The challenge for school science*. London: Harvester Wheatsheaf.
- Driver, R. (1983). *The pupil as scientist?* Milton Keynes: Open University Press.
- Furtak, E. M. (2006). The problem with answers: An exploration of guided scientific inquiry teaching. *Science Education*, 90(3), 453–467.
- Hodson, D. (1998). Science fiction: The continuing misrepresentation of science in the school curriculum. *Curriculum Studies*, 6(2) 191-216.
- Klassen, S. (2006). The science thought experiment: How might it be used profitably in the classroom? *Interchange*, 37(1-2), 77-96.
- Koballa, T., & Tippins, D. (2000). *Cases in middle and secondary science education: The promise and dilemmas*. Columbus, OH: Merrill Prentice Hall.
- Krimsky, S. (2003). *Science in the private interest: Has the lure of profits corrupted biomedical research?* Lanham, MD: Rowman & Littlefield.
- Lawson, A. E. (2005). What is the role of induction and deduction in reasoning and scientific inquiry? *Journal of Research in Science Teaching*, 42(6), 716–740.

- Lederman, N. G. (2006). Syntax of nature of science within inquiry and science instruction. In L. B. Flick & N. G. Lederman (Eds.), *Scientific inquiry and nature of science: Implications for teaching, learning, and teacher education* (pp. 301-318). Dordrecht: Springer.
- Lemke, J. L. (1990). *Talking science: Language, learning and values*. Norwood, NJ: Ablex.
- Leont'ev, A. N. (1981). *Problems of the development of the mind*. Moscow: Progress.
- Lock, R. (1990). Open-ended, problem-solving investigations: What do we mean and how can we use them? *School Science Review*, 71(256), 63-72.
- Munby, H. (1980). Analyzing teaching for intellectual independence. In H. Munby, G. Orpwood & T. Russell (Eds.), *Seeing curriculum from a new light: Essays from science education* (pp. 11-33). Toronto: OISE Press.
- National Research Council [NRC] (1996). *National science education standards*. Washington: National Academy Press.
- Rudduck, J. (1986). A strategy for handling controversial issues in the secondary school. In J. J. Wellington (Ed.), *Controversial issues in the curriculum* (pp. 6-18). Oxford: Blackwell.
- Rudolph, J. (2005). Inquiry, instrumentalism, and the public understanding of science. *Science Education*, 89(5), 803-821.
- Schwartz, R. S., Lederman, N. G., & Crawford, B. A. (2004). Developing views of nature of science in an authentic context: An explicit approach to bridging the gap between nature of science and scientific inquiry. *Science Education*, 88(4), 610-645.
- Welch, W. W., Klopfer, L. E., Robinson, J., & Aikenhead, G. S. (1981). Inquiry and school science: Analysis and recommendations. *Science Education*, 65(1), 33-50.
- Wellington, J. (1998). Practical work in science: Time for a re-appraisal. In J. Wellington (Ed.), *Practical work in school science: Which way now?* (pp. 3-15). New York: Routledge.

Wenger, E. (1998). *Communities of practice*. Cambridge: Cambridge University Press.

Ziman, J. (1984). *An introduction to science studies: The philosophical and social aspects of science and technology*. Cambridge: CUP.

Bio

John Lawrence Bencze is an associate professor of science education in the Department of Curriculum, Teaching and Learning in the Ontario Institute for Studies in Education (University of Toronto). His teaching and scholarship focus on personal, social and environmental issues stemming from relationships among powerful members of societies, fields of science and technology and science and technology education. He is an advocate for communitarianism, balancing individual and social rights and responsibilities. He is the author of 'Private profit, science and science education: Critical problems and possibilities for action,' recently published in the *Canadian Journal of Science, Mathematics & Technology Education*.