Multiliteracies and Self-Questioning in the Service of Science Learning

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It's been said that "speech makes us human and literacy makes us civilized (Olson, 1988, p. 175). In making this observation, Olson was referring to written language and the bias it imparts both to the way we think about knowledge—how we organize it, store it for reuse—and the cognitive consequences of schooling and literacy; in short, a bias favoring the written text over the oral tradition. Or, extending Olson's observation slightly, one might call it a bias that favors reading and writing over talking and doing. This bias would seem to have implications for the fields of reading and science education, especially when considering that historically there have been tensions between the two fields that have centered around ideological differences about the value of the written text versus hands-on-experience (White, 2001;Yager, 2001).

These tensions have eased considerably in the last few years, however, as both reading and science educators have come to appreciate the fact that good teachers engage learners in active inquiry using multiple forms of literacy. For example, CD-ROMs, videos, the Internet, print materials, hypertexts, and hypermedia can all be used to supplement and complement students' hands-on inquiry into photosynthesis, electro-magnetism, oxidation, and so on. Effective science instruction connects students' multiliteracies to science learning. It also enlists the National Science Education Standards' concept of scientific literacy, which involves, among other things, encouraging students to ask their own questions about their everyday experiences in the world (National Research Council, 1996).

The purpose of this chapter is to explore the implications of literacy in its multiple forms (e.g., print, visual, digital) for science instruction. Specifically, I focus on the role of students' questions in constructing knowledge about science texts. Toward that end, the chapter is divided into three sections: the first section defines *multiliteracies* and situates this concept within social constructionist learning theory; the second section examines several assumptions underlying the literature on self-questioning; and the third draws implications from this literature for using multiliteracies and self-questioning in the service of science learning.

Multiliteracies and Social Constructionist Learning Theory

The term *multiliteracies* refers to literacies that extend beyond print-based, alphabetic texts. A coined term, *multiliteracies* is most closely associated with the New London Group (Cope & Kalantzis, 2000), an interdisciplinary group of scholars who argue that all meaning-making is multimodal and that new information communication technologies and media (e.g., the Internet, hypermedia, CD-ROM) make it unreasonable to speak of literacy in the singular or to view literacy as being based on written language only:

> What we might term 'mere literacy' remains centred on language only, and usually on a singular national form of language at that, being conceived as a stable system based on rules such as mastering sound-letter

> correspondence. This is based on the assumption that we can actually discern and describe correct usage. Such a view of language must characteristically translate into a more or less authoritarian kind of pedagogy. A pedagogy of Multiliteracies, by contrast, focuses on modes of representation much broader than language alone. These differ according to culture and context, and have specific cognitive, cultural, and social effects. In some cultural contexts—in a multimedia environment, for instance—the visual mode of representation may be much more powerful and closely related to language than 'mere literacy' would ever be able to allow. Multiliteracies also creates a different kind of pedagogy: one in which language and other modes of meaning are dynamic representational resources, constantly being remade by their users as they work to achieve their various cultural purposes. (New London Group cited in Cope & Kalantzis, 2000, p. 5)

A pedagogy of multiliteracies broadens the meaning of text and relates textual reading to oral, aural, visual, tactile, and digital modes of learning as well as to the social skills necessary for communicating and collaborating while engaged in such learning. It also draws from the literature on critical literacy, and especially on "the critical literacy skills required for assessing, selecting, and rejecting information on the basis of group-negotiated criteria relevant to the problem and the situated community of practice-learners" (Luke, 2002, p. 142). Applied to school learning (a particular kind of community of practice-learners), a pedagogy of multiliteracies assumes that teachers will design and evaluate projects on a broader basis than is typically the case for print-based, alphabetic literacy. An example of how this might work is provided by the New London Group. In this example, we see that an evaluation of a school desktop publishing project calls for an expanded view of what counts as the literate features of the project:

> Desktop publishing puts a new premium on Visual Design and spreads responsibility for the visual much more broadly than was the case when writing and page layout were separate trades. So, a school project can and should properly be evaluated on the basis of Visual as well as Linguistic Design, and their multimodal relationships. (New London Group cited in Cope and Kalantzis, 2000, p. 29)

A pedagogy of multiliteracies is compatible with a *social constructionist* theory of learning, which is not to be confused with a *social constructivist* theory of learning. Although the term *social constructionism* is frequently used as a synonym for *social constructivism*, there are numerous reasons for not conflating the two concepts (Hruby, 2001). Constructivism, generally, has become a catch-all term for a collection of theoretical approaches to learning that rely for their explanation on the cognitive developmental processes individuals use in deriving conceptual (abstract) understanding from their lived experiences. Social constructivism (Bruner, 1986) is concerned with how factors outside the head, such as the culture of a classroom and the structural aspects of schooling form, rather than merely affect, what teachers and students do in the name of teaching and learning. Teachers whose belief systems align with social constructivism also believe that the ways in which students perceive themselves in a particular context (e.g., a science class) will mediate their motivation to learn (or not learn) the content of that class.

In contrast, social constructionism, which is of interest in this chapter, views language as the central mediating factor in what learners come to understand about their lived experiences and texts of various kinds. To subscribe to a social constructionist perspective on learning is to believe that meaning is built through particular conventions of language on which members of a particular community agree and act. Thus, in Gavelek and Raphael's (1996) explanation of how one comprehends text from a social constructionist perspective, it is the language of the classroom and how it is used to build particular meanings that is important:

> [A social constructionist perspective] has the potential to shift our focus on talk about text away from seeking 'facts' or 'truths' toward constructing 'interpretations' and offering 'warranted justifications' for interpretations. From this perspective, the teacher's role would shift from asking questions to ensure that students arrive at the 'right' meaning to creating prompts that encourage students' exploratory talk….Teachers would encourage talk that elicits a range of possible interpretations among individuals reading and responding at any given time. Teachers would also encourage talking about previously read texts because individuals construct different readings at different periods in life or within different contexts….Textual meaning is not 'out there' to be acquired: it is something that is constructed by individuals through their interactions with each other and the world. (p. 183)

The centrality of exploratory talk in mediating what students are thought to comprehend from textual readings—whether print, oral, aural, visual, digital, or some combination of these multimodal forms of literacy—supports the use of self-questioning, a strategy that has a long and rich history in the fields of both reading and science education. The research on this strategy and some of its underlying assumptions are explored next.

Self-Questioning

Students who generate questions for the purpose of finding "answers to questions derived from curiosity about everyday experiences" are participating in scientific inquiry as defined by the National Science Education Standards (National Research Council, 1996, p. 22). They are also comprehending more of what they read from traditional textbook assignments, though arguably their self-questioning in this capacity is guided more from textual content than from their own curiosity. Regardless, experimentally-based research on self-questioning as a strategy shows that it is one of seven types of instructional strategies deemed effective in improving students' comprehension of traditional print texts (National Reading Panel, 2000).

Of the 450 text comprehension studies that members of the National Reading Panel (2000) identified as meeting their stringent criteria for scientific analysis, 27 involved studies of self-questioning in grades 3 through 9 (mode = grade 6). According to the Panel's report, "there was stronger evidence for near transfer than for generalized effects…[with only] mixed evidence that general reading comprehension is improved on standardized, comprehension tests" (p. 4-45). Moreover, the Panel concluded that "question generation may…be best used as a part of a multiple strategy instruction program" (p. 4-45).

As with all reports, that of the National Reading Panel must be read with a clear understanding as to the limitations of its findings. For example, the Panel did not address issues specific to English language learners or to scientific literacy. Nor did it include studies using qualitative research designs, the absence of which severely limits what can be known about the contexts in which instruction occurred. A general assumption underlying the 27 studies the Panel analyzed was that the reading process typically consists of students working individually to extract information from printed texts. This rather narrow view of comprehension risks disenfranchising students who may learn better in more socially interactive settings or whose multiliteracies (e.g., oral, aural, visual, and digital) span a broader range than those typically emphasized in school-based print literacy.

Although agreeing with the National Reading Panel's (2000) conclusion that explicit instruction in self-questioning can improve students' comprehension, members of the Rand Reading Study Group (2002) pointed out the need to consider the type of reader involved:

> Sometimes this explicit instruction is helpful for low-achieving students but is superfluous for normal readers….Sometimes improvement occurs not because of the specific strategies being taught but because students have been actively interacting with the texts. This active interaction triggers the use of strategies that inactive learners possess but do not normally use. Explicit instruction generates the immediate use of comprehension strategies, but there is less evidence that students continue

to use the strategies in the classroom and outside of school after instruction ends. (p. 33)

An assumption underlying the effectiveness of direct instruction in a strategy such as self-questioning with low-achieving readers is that classroom teachers will be sufficiently prepared and have the time to respond flexibly to students' needs for scaffolding and feedback on their questioning. Unfortunately, this is often not the case. For example, it is not uncommon for elementary teachers to take little satisfaction in teaching science, a subject for which they feel underprepared (Schoenberger & Russell, 1986; Tilgner, 1990). In addition, according to the multiple case study research of Edmunds, Jones, and Michaels (2002), elementary teachers often feel pressured to teach reading and math at the expense of science.

But competing demands on teachers' time are not the only deterrent to teaching students how to self-question as means of acquiring scientific literacy. Students with a history of reading difficulties present particular challenges to science teachers. Because they read so infrequently, these students typically will not have acquired the requisite background knowledge, skills, and specialized vocabulary needed for comprehending most science materials. Some teachers understandably become frustrated when this occurs, and they sometimes resort to what Finn (1999) calls a "domesticating" education. That is, they expect less of low-achieving readers in exchange for the students' good will and reasonable effort in completing their assignments, which typically require little, if any, reading.

Even high school science teachers who rate themselves well prepared to teach their subject matter specialty often find that changing classroom structures and practices to make room for students to engage in self-questioning is difficult to do. For example, Alvermann and Hayes (1989) found in their long-term classroom intervention study that the inservice teachers with whom they worked were unsuccessful in curbing certain classroom practices that led to teacher-dominated questions, and this, despite the fact the teachers had hoped to encourage more contributions from students. Similarly, in another intervention study aimed at changing classroom interaction patterns so as to accommodate students' voices, middle school teachers discovered that interrupting certain gendered discursive practices in talk about texts was easy to theorize but difficult to accomplish (Alvermann, Commeyras, Young, Randall, & Hinson, 1997).

In cases where science teachers have been successful in promoting students' self-questioning, the change has occurred largely as a result of working within a social constructionist framework to study the mediating effects of such questioning and/or using computers, the Internet, and multimedia software to target specific interests and create a need for student dialogue. For instance, Chin (2001) conducted a case study involving six Grade 8 target students as they worked through a nine-week chemistry unit. The hands-on laboratory activities in which these students were engaged included the following:

- *Separation of salt-sand mixture*. This was an open-ended problem-solving activity where the students had to devise a method for separating a mixture of salt and sand.
- *Boiling point lab*. The students had to plot and compare the temperature graphs for plain water and salt water when ice and salted ice were heated until boiling.

- *Chromatography*. The students used paper chromatography to separate the dyes in the ink from different coloured marker pens and calculated the retention factor (R_f) for each dye.
- *Chemical change: Reaction between zinc and dilute hydrochloric acid.* The teacher gave a demonstration on how to carry out the activity. The students then performed the activity individually in their groups.
- *Acids and bases*. The students were required to determine if some common household substances (vinegar, baking soda, water, salt water, ammonia, aspirin, antacid tablets, alcohol, bleach, coca-cola, coffee, mouthwash, and lemon juice) were acidic, basic, or neutral using cabbage juice and blueberry juice as indicators. (Chin, 2001, pp. 3-4)

As the students worked, they were encouraged to verbalize their thoughts. Chin used the students' think-alouds in conjunction with her field notes, the transcripts of videotaped classroom discourse, the students' learning journals about things that puzzled them, and their interview data to analyze how the types of questions students asked mediated the knowledge they constructed. Similar to Scardamalia and Bereiter (1992), Chin found two types of student questions: basic information questions and wonderment questions. Examples of basic information questions included factual-level processing of textual material (e.g., recalling the dictionary definition of salt) or procedural-level processing to clarify a particular task (e.g., "Did she [the teacher] say to put the salt in a pan?").

Wonderment questions, on the other hand, consisted of higher-level processing, such as asking the following: hypothesis-verification questions (e.g., “How about we pour some water in here?”); anomaly detection questions (e.g., “How do you know the salt’s in there?”); application questions (e.g., “What is the R_f used for?”); and planning or strategy questions (e.g., “How are we going to bring the salt back?”).Chin reported that on various occasions when students were not encouraged to ask wonderment questions, they did not generate them spontaneously. This suggested to her that leaving such questioning to chance was tantamount to letting students’ puzzlements go undetected—in effect, stifling further inquiry.

Using molecular modeling computer software to improve high school students’ understanding of chemical bonding, Barnea and Dori (1999) demonstrated the value of virtual laboratory sessions. In fact, as Treagust and Chittleborough (2001) have pointed out, the use of virtual labs in combination with multimedia software that contain, text, sound, images, animations, and interactive capabilities can increase opportunities for students to self-question and engage in creative dialogue. Although virtual labs and chemistry CD-ROMs, such as the *Periodic Table CD*, can enhance and elicit student questions about representations of chemistry at the macroscopic, microscopic, and symbolic levels, Brooks and Brooks (1995) remind us that these new instructional aids should be viewed as supplements, not substitutes, for actual laboratory experiences.

Similarly, in referring to a review of the research on the use of technology and multimedia software to teach biology—including activities such as having students generate and e-mail questions to distant biology experts—Wandersee (2001) sounds this cautionary note:

> Within the past decade, the availability of biology teaching resources and instructional alternatives has increased dramatically. The real question now is: What shall I choose that best teaches what I have already planned to teach? It's very easy to get side-tracked….Another danger lies in using corporate-financed, attractively packaged 'free' teaching materials that may be far from neutral on issues that affect their financial viability. (pp. 213-214)

Wandersee goes on to recommend that biology teachers look to sound research and the National Science Education Standards (National Research Council, 1996) for ideas in developing students' critical and scientific literacy. Specifically, he suggests that teachers use the standards for guidance in helping students pose problem-solving questions as they work with peers during pre- and post-laboratory analytical sessions—a recommendation not unlike Chin's (2001), interestingly enough.

This call for teachers to guide students' self-questioning seems largely based on the assumption that scaffolded instruction meshes well with a social constructionist theory of how students learn. The call also seems well placed, especially given that so few students spontaneously ask higher-order questions (White & Gunstone, 1992), or for that matter, questions of any kind (Alvermann & Moore, 1991; Alvermann, O'Brien, & Dillon, 1990; Alvermann et al., 1996). More than a decade ago Dillon (1988) noted the same paucity of student-posed questions, and judging from more recent reviews of the literature on question generation as a means of improving students' comprehension (Nist & Simpson, 2000; Pressley, 2000), the situation has not changed much. Granted, the research-backed strategies are there for teaching this essential skill (e.g., Manzo, 1969;

Palincsar & Brown, 1984; Singer & Donlan, 1982), but school and classroom structures that would allow for more student-centered learning are slow to evolve (Alvermann et al., 1996; Barr, 2001).

Although student self-questioning does not show up as much as one might wish in actual classroom practice, it shows no evidence of declining in popularity as a topic of inquiry among science education researchers. According to White's (2001) quantitative and qualitative analyses of changes in topics in science education research as reported in ERIC for the past 30 years, the number of studies on questioning (though not limited to self-questioning) has remained fairly constant since1966, ranging from a high of 98 in the 5-year-period from 1966-70 to a low of 66 in 1976-1980. In 1991-1995 (the last reported 5-year-period), there were 77 science education studies that dealt with questioning.

Much of this research has focused on students' comprehension of text-based questions, including questions that students formulated in response to textual material (e.g., Palincsar & Brown, 1984; Wong, 1985) and as participants in conceptual-change learning (e.g., Guzzetti & Hynd, 1998; Watts, Gould, & Alsop, 1997). Non-text knowledge-based questions—for example, the wonderment questions of Chin's (2001) research—were the focus of a much smaller body of research. These are the questions that reflect students' interests in finding out more about the world in which they live; in short, they are the questions that Scardamalia and Bereiter (1992) regard as having the potential to generate further scientific inquiry. Keys' (1998) study of Grade 6 students who worked in small groups to generate questions to open-ended science investigations and Chin's (2001) work with Grade 8 students to explore student-generated questions are good examples of research that seeks to study the mediating effects of such questioning on students' science learning.

In sum, the research on self-questioning points to a heavy emphasis on formulating questions in relation to print-based (mostly textbook) material. This bias is not unlike the one alluded to at the start of the chapter. Although science educators (and to a lesser extent, reading educators) have expressed interest in the use us new interactive technologies and multimedia software to "empower the student and change the emphasis from teacher-centred to more student-centred learning" (Tan & Tan cited in Treagust & and Chittleborough, 2001, p. 259), in truth, this interest has failed to find its way into researchers' agendas. This fact, coupled with the scarcity of research on non-text knowledge-based questions, will make tying the extant literature on self-questioning to students' multiliteracies in the last section of this chapter a bit more challenging than I might have anticipated.

Implications of Multiliteracies and Self-Questioning for Science Learning

Perhaps a good starting point in this section on implications is the following excerpt taken from an audio clip[1] of the courtroom scene from the movie *A Few Good Men*. As the scene opens, Lieutenant (j.g.) Daniel A. Kaffee (played by Tom Cruise) is questioning Lieutenant Colonel Nathan Jessep (played by Jack Nicholson) about Nicholson's knowledge of the circumstances surrounding the death of a soldier:

Nicholson: "You want answers?"

Cruise: "I think I'm entitled."

Nicholson: "You want answers?"

Cruise: "I want the truth!"

Nicholson: "You can't handle the truth!"

As one of my colleagues[2] at the University of Georgia observed in his response to this exchange, the question is not whether one can handle the truth, but rather, just exactly what makes something true?

This seems a pertinent observation and one that speaks to the connection I am attempting to make between students' multiliteracies and the research on self-questioning. A social constructionist theory of learning would argue that generating questions aimed at shifting away from a focus on "facts" or "truths" and toward "warranted justifications" of particular interpretations is what science learning should be about. Self-questioning that prompts a range of multiple interpretations that can be evaluated based on evidence (oral, aural, visual, tactile, digital, and print) is part and parcel of learning to become scientifically literate. It is also central to making use of a host of literacies that too often take a back seat to what Street (1995) labels the "autonomous" model of reading and writing whereby *Literacy* is perceived as being singular in form and spelled with a big *L*.

The tendency to assume that such a model is also "natural" (and thus free of any ideological position) is indicative, in turn, of our tendency as educators to reify written language. I want to suggest that the understandings to be gained from designing research studies of self-questioning which permit students' multiliteracies to show themselves will move us a step closer to a knowledge base that is supportive of science learning, specifically, and scientific literacy more generally. A pedagogy of multiliteracies, compatible as it is with social constructionist learning theory, offers researchers a ready instructional framework within to study the mediating effects of students' self-questioning on their learning of science content.

However, as was pointed out in the last section, regardless of what research may say about the efficacy of teaching students to self-question, the assumption that elementary classroom teachers will feel prepared to accommodate an increase in this kind of questioning—and particularly, to welcome questions about non-print texts—is a dangerous assumption to make. From all indications of the research to date, elementary teachers do not have a strong background in teaching science. This fact, coupled with the pressures being exerted on them to teach reading and math for longer blocks of time, would seem to point to potential conflicts. For as work by the Strategic Literacy Initiative at WestEd (Greenleaf, Katz, & Schoenbach, 2001) has shown, it is not until teachers have the time and feel comfortable in appropriating the social practices and conceptual tools necessary for effecting change that they can hope to alter school and classroom structures that militate against student-centered learning.

Finally, the assumption that students' multiliteracies might be tapped through the use of new interactive communication technologies and multimedia software, remains just that—an assumption. Although the demands and complexities of living in a highly globalized and technologized society have never been more apparent, educators are a conservative lot, and generally distrustful of the "whistles and bells" so often associated with high tech learning. And, in fact, the extent to which the Internet, hypermedia, and other new technologies effectively support literacy teaching and learning in science classrooms is unknown. There is little empirical research on the topic generally, and even less that applies specifically to self-questioning (National Reading Panel, 2000). A related issue is the paucity of available research sites given that so few schools have integrated the new information communication technologies into their curricula (Leu, 2000). Nonetheless, given that the everyday out-of-school literacy practices among the youth of this country are changing at an unprecedented pace, can it be long before we in education let loose of some of the comfortable assumptions that have ceased to serve us well?

Author Notes

[1]Audio clip. Available http://cc636243-a.twsn1.md.home.com/sond0107.htm [Downloaded 7/6/00]

[2]Rieber, L. (2000). What is really true? A lesson in understanding constructivism. Available http://it.coe.uga.edu/~lrieber/constructlesson.html [Downloaded 7/6/00]

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