5 Scientific Literacy, Discourse, and Epistemic Practices[1]

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O que é?

Introduction

Proponents of *scientific literacy* often tie the goals of science education to broad societal ideals (e.g., AAAS, 1993). These ideals extend beyond reading and writing scientific texts and beyond understandings of scientific concepts and procedures, and often concern knowledge required for effective citizenship. Rationales for scientific literacy include the economic well being of a nation, the perceived need for technological knowledge among citizens, and the value of scientific and technological knowledge for supporting social justice and taking actions in society (DeBoer, 2000; Hodson, 2003; Roberts, 2007). Often lost in the discussion of what (or whose) knowledge is of most worth for citizenship is the central role communication plays in the construction and assessment of knowledge. A focus on scientific literacy can bring to the foreground the importance of language in knowledge production, in both scientific and education communities. linguagem

Discourse contributes in multiple ways to the production of scientific knowledge, from the banter in the process of discovery (Garfinkel, Lynch, & Livingston, 1981) to the development of specific genres for persuasion (Bazerman, 1988). Similarly, in education discourse processes are central to the everyday activity of knowledge construction. Discourse is central to the ways communities develop community norms and expectations, define common knowledge for the group, build affiliation, frame knowledge made available, and provide access to disciplinary knowledge, and invite or limit participation (Cazden, 2001; Gee & Green, 1998; Kelly & Green, 1998). Thus, the learning of individuals is situated in the cultural practices and norms of a relevant community, a community that changes over time as members take action to change the social knowledge, norms, and practices. A central mediating feature of these communities is language. Knowledge is constructed and reconstructed as members of a community bring together their respective experiences, local knowledge, and ways of being (Wells, 2000). While discourse practices vary in purpose across professional and educational settings, uses of language are central to both the creation and communication of knowledge in each setting. Thus, the ties of language to knowledge construction merit a closer look at literacy and epistemology.

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In this chapter, I consider views of scientific literacy and how the use of language is related to learning and knowing. I begin by drawing from work in the field of literacy research, before turning to science studies and science education. Through the use of philosophy of science and various empirical studies of scientific practices across settings, I propose that the goals of science education include developing epistemic practices among learners. I then shift to discuss how, when conceiving of language and knowledge as ideological, we need to consider how knowledge is legitimated through discourse. Finally, I draw some practical applications of this perspective.

Literacy, Language and Knowledge

Language in Scientific Literacy

Norris and Phillips (2003) make a distinction between two senses of scientific literacy in the science education research literature. They define fundamental science literacy as coming from the ability to read and write on the subject of science and the derived sense of scientific literacy as encompassed in being knowledgeable, learned, and educated in science (Norris & Phillips, 2003, p. 224). Their argument continued to note that reading and writing in and about science do not stand alone as mere devices for the recording and communication of science (Norris & Phillips, 2003); but rather, science literacy in the fundamental sense serves as a central component in building the conceptual, epistemic, and societal dimensions associated with a derived sense of literacy. Norris and Phillips argue that there exist connections between the broad citizenship goals of scientific literacy articulated in science education reform documents and the uses of written and spoken language in educational settings. While I agree with Norris and Phillips that the derived sense of scientific literacy is dependent on the fundamental sense of literacy, particularly as related to the social and discourse features of scientific practices, there are two ways that this distinction needs to be examined closely. First, learning literate practices in a fundamental sense entails acculturation to a broader set of ways of speaking, acting, and being in the world. Second, this acculturation involves the communication, and thus privileging, of some(one's) knowledge. Thus, choices about which types of literate practices entail choices about types of citizenship. To these issues I now turn.

Discourse Practices, Socialization, and Literacy

Literacy entails engaging in the discourse practices of a group or groups. Therefore, to understand views of literacy, we need to consider discourse broadly construed. I will use the term discourse to refer to ways of using language in social contexts. Each use of language is tied to specific instances of activity, and enacts specific identities. Gee (2001a) offers some clarity around the relationship of discourse and literacy. Gee's argument is that discourses are social practices that combine with ways of acting to form *Discourses*—"ways of being in the world … forms of life which integrate words, acts, values, beliefs, attitudes, and social identities as well as gestures, glances, body positions, and clothes" (p. 526). A key feature of Discourses is that they are not mastered through overt instruction, but

Relação entre discurso e literacy

rather, through participation as a member of a group exhibiting the practices of the particular Discourse. Gee distinguishes between primary and secondary Discourses. People learn a primary Discourse through enculturation into their first culture, primarily centered in one's family and other associated social organizations. Secondary Discourses are learned through participation in social groups and acculturation. Gee defines literacy as "the mastery of or fluent control over a secondary Discourse" (p. 529). These secondary Discourses are powerful as they allow for analysis and criticism and, in particular, for critique of one's primary Discourse. This perspective has application in the design of science pedagogy, as the view suggests that students need time and opportunities to participate in activities that engage them in the new secondary Discourses—that is, language use needs to be connected to purposeful activity where students learn social meanings of science communities through participation with more knowing others.

Relação com Epos I

Further extending Gee's view of literacy into social practice, Green and her colleagues consider literacy in terms of the "literate practices" of learning disciplinary knowledge (e.g., Santa Barbara Classroom Discourse Group, 1992). This view of literacy, derived from anthropology and sociolinguistics, examines ways spoken and written texts are embedded in social processes and cultural practices. Through the study of literate practices across disciplinary areas, the Santa Barbara Classroom Discourse Group (1992) defines literacy as socially constructed and situationally defined and redefined within and across different social groups as members engage with, interpret, and construct text (Castanheira, Crawford, Dixon, & Green, 2001, p. 354). This view suggests that literacy is not achieved, but rather can be viewed as literate actions members of groups take as they engage with texts in everyday life. This view is similar to that of Gee. In both cases literacy involves more than just reading and writing texts, but rather entails actions, beliefs, values, social practices, and identity formation (Gee & Green, 1998).

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Viewing literacy and learning in this way suggests that the social practices of science interact with, draw upon, and in certain circumstances are similar to, other specialized ways of talking, writing, engaging, and being in the world. This view of literacy suggests that social groups construct the semiotic systems, roles and relationships, norms and expectations, and rights and obligations that are signaled through the actions and interactions among members (Santa Barbara Classroom Discourse Group, 1992; Kelly & Green, 1998). Therefore, the study of how the discourses of disciplinary knowledge are constructed in educational settings needs to include examination of the ways social groups affiliate, build cultural practices through interaction, and establish common knowledge within the group or class (Edwards & Mercer, 1987). These ways of being suggest that learning to engage in the discourses of science requires developing new repertoires for interaction with people, texts, and technologies. The consideration of identity then becomes crucial for the understanding of the socialization processes of education and how affiliation or alienation might occur through acculturation processes (Gee, 2001b; Brown, Reveles, & Kelly, 2005). This view suggests that identity is situational, contextualized, and becomes evident through discourse

Pertencimento a uma cultura: EDP pode proporcionar and interaction—members of groups make decisions about how to position themselves with discourse that draws from a repertoire of ways of interacting (Brown & Spang, 2008; Reveles, Kelly, & Durán, 2007).

The Ideological Nature of Language and Knowledge

The view of literacy that entails learning a secondary Discourse (Gee, 2001a), with all the associated values, beliefs, and ways of being in the world, suggests that learning to participate in a social context is not value neutral. This argument is made forcefully by Street (2001) in referring to the "new literacy studies." Street argued that initial studies of literacy often presupposed an "autonomous" view of reading and writing. This view suggests that literacy be conceptualized in "technical terms, treating it as independent of social context, an autonomous variable whose consequences for society and cognition can be derived from its intrinsic character" (pp. 431–432). Street proposes an "ideological" model of literacy that views "literacy practices as inextricably linked to cultural and power structures in society and to recognize the variety of cultural practices associated with reading and writing in different contexts" (pp. 433–434). Street uses ideological to refer to the social, cultural, and pragmatic dimensions of literacy practices—but not the "false consciousness" posited by Marxist views of ideology. The ideological model suggests that literacy practices are situated in some context with some set of purposes, uses, goals, and so forth. Street suggests moving away from only studies of literacy as an individual cognitive tool to consideration of the ways that language-in-use is situated in culture and power, in institutions, and in ideologies of communication in the contemporary world (p. 437). Thus, from the contemporary views of literacy educators, the study of literacy should include ethnography of communication, communities, and institutions. Such work applied to science education may entail investigations of the many ways that science is constructed—that is, as interactionally accomplished through discourse and actions—both within schooling and in the many other contexts where local knowledge and practices involving the study of nature are evoked (Roth & Calabrese Barton, 2004).

Directions for Research Concerning Scientific Literacy

Drawing from science studies (i.e., multidisciplinary study of scientific knowledge and practices) and the learning sciences (i.e., multidisciplinary study of learning and learning environments), Duschl (2008) proposes a focus on three integrated domains for science education: conceptual structures and cognitive processes; epistemic frameworks; and social processes shaping communication in science. A shift toward these domains would move science instruction beyond a traditional focus on the proposition knowledge of final form science, that is, the conclusions of scientific practices often articulated as concretized theories, laws, and facts. Such a move is consistent with the arguments above about learning through participation in discourse processes, but still leaves open the curricula decisions about what counts as science. Roberts (2007) identified two central

visions for scientific literacy in the field of science education. One vision turns inward toward the products and processes of science, while a second vision examines the situations citizens may encounter with a scientific component (p. 730). For each vision, the relevant conceptual knowledge, epistemic practices, and communicative demands are contingent upon what counts as knowledge and practice for some social group. As described above, the knowledge and practice are dependent on discourse in situated contexts of use. Thus, in this section I propose two avenues for research in scientific literacy that concern how what counts as knowledge and practices is accomplished within and across social groups, and how such knowledge and practices are legitimized.

I discuss first the importance of learning in epistemic practices of science as part of the secondary Discourse of science and, second, the need to consider how certain discourses come to count as science in schools. There are, of course, many other plausible ways to research scientific literacy and ways of going about such research. I am not suggesting that research in scientific literacy be limited to these avenues, but rather, that the views of literacy, language, and knowledge sketched in the previous sections have such implications for research.

Epistemic Practices and Science Learning

Studies of epistemology in science education have tended to focus either on personal theories of knowing as related to learning, or disciplinary views of knowledge that inform curriculum or assessment development, but few such studies examine the ways that disciplinary knowledge is interactively accomplished through discourse and actions in local settings (Kelly, Chen, & Crawford, 1998). My argument here is that the three knowledge domains outlined by Duschl (2008) can be mutually supportive through a focus on the epistemic practices associated with assessing, producing, communicating, and evaluating knowledge claims (Kelly, 2008). While I do not believe that a focus on epistemic practices should be the only focus of research related to science pedagogy, it does offer some productive ways of examining the intersubjective nature of scientific literacy.

The focus on epistemic practices derives from a social epistemology. Developments in the philosophy of science have refocused the epistemic subject from an individual mind to a relevant community of knowers (Longino, 2002; for review, see Kelly, 2008). The move to an intersubjective paradigm for epistemology is particularly relevant in the construction of scientific knowledge, as found in both professional and educational contexts. Community practices and values play important roles in empirical research. These practices and values have been well documented in science studies (e.g., Knorr-Cetina, 1999; Lynch, 1993). Social practices of epistemic communities in science fields govern research directions, control outlets for publication, define the socialization of new members, and formulate and assess knowledge claims through collaborative research endeavors (Jasanoff, Markle, Petersen, & Pinch, 1995). A social epistemology has relevance for education in many ways, but perhaps most centrally in ways that people are initiated into particular frames of reference through language and participation in cultural practices (Wittgenstein, 1958). Viewing science as social knowledge contrasts with some paradigms for educational research, which have focused on how individual students learn particular concepts (e.g., Pfundt & Duit, 1991). The alternative frameworks movement, conceptual change, and various forms of constructivism, have largely focused on individual learners. This has been true even if the individual learners were learning in a social situation. In such cases, epistemology was often reduced to how individual learners conceptualized knowledge in their own personal, idiosyncratic ways. A focus on epistemic practices offers an alternative.

An emerging group of scholars are examining the knowledge building in everyday educational contexts (Jimenez-Aleixandre & Reigosa, 2006; Kelly, 2008; Kelly, Chen, & Prothero, 2000; Lidar, Lundqvist, & Ostman, 2006; Sandoval, 2006; Wickman, 2004). The foci have been on discourse of students and teachers around the practical investigations of science, as well as discourse around aspects of knowledge assessment and evaluation. A common characteristic of these studies is a centering of the epistemic subject as a relevant social group, or minimally within a social group. By focusing closely on the ways that knowledge claims are formulated and assessed through discourse processes, these studies offer ways to examine how evidence for changes in conceptual understanding, scientific reasoning, and science in sociopolitical contexts can be understood in everyday learning situations. This focus connects to theories of social epistemology, as we may think of pedagogy as providing opportunities to engage in the knowledge and practices of a relevant community. The focus on situated epistemic practices poses challenges for students and researchers.

A focus on epistemic practices situates science learning in social contexts and places a new set of literacy demands on students. The literacy demands entailed by the epistemic practices of science education suggest a need for studies of language in use in multiple settings. These studies need to account for the multimedia, interactionally accomplished nature of scientific reasoning in situationally defined settings (Lemke, 2000; Roth & Lee, 2002). Such studies would need to examine uses of language in spoken and written forms across different temporal units—that is, moments, lessons, science units and projects, histories of ideas (Kelly, 2008). What counts as science, who can participate, and how science is accomplished among members of a group, are all manifest in moment-to-moment interactions embedded in social histories and cultural traditions (Kelly & Green, 1998). Thus, the study of literacy demands of the many actors relevant to school science (scientists, activists, teachers, students, and parents, among others) may shed light on the processes of representation, communication, and evaluation of the evidentiary bases of knowledge claims—often key features of the derived sense of scientific literacy, and open to the second vision of knowledge for citizenship suggested by Roberts (2007). The pedagogical emphasis on evidence use suggests the need to examine ways that social practices are instantiated, communicated, appropriated, interpreted, applied, and change over time. Such a research focus may identify ways science pedagogy supports or constrains students' learning opportunities.

A focus on epistemic practices that situates science learning in social contexts places a new set of demands on researchers examining learning. A focus on epistemic practices suggests units of analyses that include multiple actors, the ways that roles are established and positioned, norms and expectations, the mediating artifacts, and local history of sociocultural practices. Activity theory provides a methodological approach that considers a distributed view of learning by taking into consideration the many dimensions of collective, culturally mediated activity (Engestrom & Miettinen, 1999). This unit of analysis thus requires that the study of inquiry examine these many dimensions, through systematic, careful analysis of the concerted actions of social groups (Kelly, 2008).

The focus on epistemic practices and social knowledge presupposes an interaction of more knowledgeable others and students in dialogue. This perspective raises questions about who and what counts in the negotiation of (what is taken for) legitimate knowledge. I would be remiss to not consider some of the legitimation issues in science curricula in the discussion of scientific literacy.

Legitimation Issues in Science Curricula

Whether considering the broad goals of science for citizenship, or the more narrow goals of the particular ways science texts are written and read, questions about what counts as science arise. A number of questions can be raised about scientific literacy from this point of view. How should a community decide which (whose) knowledge is worthy of inclusion in the curriculum? Who can legitimately make such decisions? What ought to be the nature of debate regarding the processes for choosing knowledge worthy of the students' attention? Such questions are not easily answered. For example, Eisenhart, Finkel, & Marion (1996) suggested that important US-based reform documents (AAAS, 1993; NRC, 1996) while claiming the goal of scientific literacy broadly defined, emphasize the theoretical and factual nature of science, at the expense of other goals related to the nature of science, understanding the societal impact of science, and a developing socially responsible science. In another example, Roth and Lee (2002) note that conceptions of scientific literacy often presuppose a view of knowledge acquisition on the part of individuals, rather than knowledge of, or for, a collective. By viewing literacy for a collective and assuming a distribution of expertise (Norris, 1995), Roth and Lee note that science education can be developed as and for sociopolitical action. Finally, Hodson (2003) noted that while documents such as Science for All Americans (AAAS, 1989) call for a more socially compassionate science, the authors did not suggest that scientific literacy include the "capacity and willingness to act in environmentally responsible and socially just ways" (p. 652). Hodson makes the case that, while notions of scientific literacy are of some value, there is a need to develop greater interest among young learners and to create a science for sociopolitical action.

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Just as questions can be raised about the views of literacy underlying definitions of scientific literacy, educators continue to challenge assumptions about science. Critiques of science have come from feminist perspectives (e.g., Calabrese Barton, 1998), multicultural education (e.g., Krugly-Smolska, 1996), critical theory (e.g., Kyle, 1991), and from the point of view of indigenous knowledge (e.g., Aikenhead, 1997). Science and scientific knowledge will continue to be contested (e.g., Calabrese Barton & Osborne, 1998; Harding, 1993), whether framed under the banner of scientific literacy or not, and these challenges pose important questions for the future directions of research in scientific literacy. The contested nature of science leads to the need for careful consideration of knowledge legitimation issues (Habermas, 1990). For example, Aikenhead (2006) argues that in much of North America the "pipeline ideology" of science education orients curricular choices away from knowledge students may need toward the knowledge of academic scientists.

Knowledge legitimation poses difficult questions for considerations of future direction for scientific literacy. Undoubtedly, there is a certain power in science and its contributions to technology for solving problems. Whether the science under consideration is the final form, de-politized often found in science textbooks (and sometimes articulated in recent standards-based reforms, e.g., see Bianchini & Kelly, 2000), or science for sociopolitical action as suggested by Hodson (2003), there exist certain tensions between the value of students' voices in contributing to curricular decisions and the value of expanding the horizons of students through inculcation of certain knowledge, beliefs, and values. Decisions about whose knowledge counts have a long history and indeed are central to important debates in education (Apple, 1993). These debates are healthy; as a research community, we can continue to argue for legitimation of knowledge from different moral points of view. Nevertheless, such discussions are difficult. In earlier work (Kelly, 2006), I drew from Strike (1995) to propose a framework of critical discourse to consider how, given the epistemic plurality of modern societies, questions of importance can be discussed across differences. The proposed framework involves considering a set of critical dialogues centered on building public reason, rather than defining a priori what counts as knowledge, science, literacy, and so forth. Education can have a key role in developing the capacity of citizens to engage in critical dialogues and can benefit from such dialogues when considering issues of knowledge legitimation.

argumentação!

Applications for Teaching and Learning Science

The arguments in this chapter center on ways of conceptualizing literacy in a broad sense, that is, tied to social action, while recognizing the important ways that discourse processes contribute to the construction of everyday life. This perspective recognizes that knowledge is of a group, and that learning the relevant discourse of a group entails participation. There are a number of practical applications that can be derived from this perspective.

First, science lessons can be organized to include the three goals for science education advocated by Duschl (2008): conceptual understanding, epistemic reasoning, and social processes. While any individual lesson may take up these foci with differing emphasis, teachers can examine and make explicit the importance of, not only understanding key scientific conceptions, but also the evidentiary support and ways of reasoning supporting these conceptions. For example, an emerging line of research in science education focuses on how students can learn to develop, assess, and critique scientific and socioscientific arguments (e.g., Berland & Reiser, 2009; McNeill, 2009; Sadler & Fowler, 2006; Sampson & Clarke, 2009; Zembal-Saul, 2009). Creating arguments involves using theoretical knowledge and relevant data and adhering to disciplinary norms. Furthermore, creating arguments entails an audience, implied or real, and sets the use of scientific knowledge in the context of persuading others about the merits of ideas. Thus, through careful attention to the uses of evidence across contexts, these studies are showing how, when properly framed as a legitimate science activity, constructing arguments can help students learn the conceptual knowledge, epistemic practices, and social processes of science. argumentação → AC

Second, the role of discourse processes is often neglected in science education settings. It is well known that science has unique discourse features and that these features are difficult for students to ascertain (Kelly, 2007). Discourse processes can be seen in almost all activities in science classrooms and other settings such as museums. While there are many ways to reconsider the uses of language in science learning, one practical application of this is rethinking how we interpret experience. Many science lessons are organized around teacher lectures, demonstrations, or student practical work that involved observation of the material world. Coming to see the natural world in particular ways, and making events recognizable and witnessable, through shared discourse is often neglected or obscured in science teaching—events are often assumed visible for the keen observer. However, greater attention to the ways that language picks out and identifies natural phenomena would help students make sense of their experiences and learn to observe in ways consistent with more knowledgeable others.

Third, the problems of science can be made problematic in science classes. I have argued that by viewing science as social knowledge and recognizing that only certain re-presentations of science are made available to students' schooling and science education in other settings involves making selections regarding possible (often implicit) views of science. Thus, even for an inward view of science, choices are made about how science gets enacted in educational settings. To achieve the citizenship view of scientific literacy (Roberts' Vision II), any of these views of science itself can be contested. Applications that concern examining science in societal contexts provide students with the opportunity to question not only the application of science, but also the scientific knowledge itself (Cunningham & Helms, 1998). For example, in Schweizer and Kelly (2005), students were asked to examine the scientific basis for human contributions to global warming. Through the production and critique of arguments around this issue, students were able to question the evidence, scientific models, and knowledge claims of proponents of different views regarding the central scientific question. This process allowed for the questioning of what counts as science among and for students in the collective discussions. Thus students were able to pose important questions about the nature of scientific modeling, levels of certainty in science, and the role of expertise is adjudicating controversy.

Concluding Thoughts

In this chapter, I have argued for a view of scientific literacy that considers the ways that language use is central to the development of community knowledge and practices. The purpose of the chapter is not to provide a comprehensive review of all of the ways that considerations of knowledge and language might intersect with scientific literacy. Rather, I have examined some notions of literacy and how literacy focused on language in use (fundamental sense, following Norris & Phillips, 2003) is related to the scientific literacy for citizenship (derived sense of literacy, following Norris & Phillips, 2003). I have proposed a research focus on epistemic practices that considers the evidentiary bases of scientific knowledge claims: ways knowledge is framed, proposed, justified, evaluated, and legitimized. Such a focus builds on relevant domains for science learning and can contribute to different visions and meanings of scientific literacy. Furthermore, I have argued that framing reform in terms of scientific literacy presupposes notions of knowledge legitimation. Questions about what counts as knowledge and science remain and are part of a healthy on-going dialogue. Directions for future research might include examining how engagement in epistemic practices provides for learning opportunities, answering descriptive questions about what and whose science counts in given contexts, and considering normative questions about what and whose knowledge should contribute to creating a more just and responsible citizenry.

Note

1. An earlier version of this chapter entitled, "Scientific literacy, discourse, and knowledge," was presented at the Linnaeus tercentenary symposium Promoting Scientific Literacy: Science Education Research in Transaction, Uppsala, Sweden, May 28–31, 2007.

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