The purpose of this paper is to propose a theoretical framework for researching literacy and language use in the science classroom. Scholarship concerning what is required for students to become scientifically literate drive the construction of the framework. The framework is composed of three interrelated theoretical ideas: (1) authenticity in science communication; (2) teaching about and providing opportunities for negotiation among multiple discourses in the science classroom; (3) Bhabha’s (1994) notion of the creation of the dialogic Third Space. Throughout the past decade, many definitions of scientific literacy have been proposed, some of which include knowledge of scientific vocabulary, understanding the nature of inquiry in science, being able to use scientific concepts in everyday life, being able to read and interpret scientific information in the popular press (Norris & Phillips, 2003). Norris and Phillips (2003) assert that reading and writing in the fundamental sense are essential for science learning, that is—developing facility with reading and writing scientific texts is
critical to developing scientific literacy in the broad sense. They argue that theories such as those found in advanced science cannot exist without the aid of written record. By extension, classroom students’ understandings (especially as developed in middle and high school) of science cannot take place without the activities of reading and writing in construction and reconstruction of scientific ideas.

The definition of scientific literacy used to coordinate the framework presented in this paper encompasses three key ideas. First is the adoption of Norris and Phillip’s (2003) contention that scientific literacy requires the ability to both read and write scientific texts in richly constructed ways. Second is the assertion that a scientifically literate person can understand and apply the fundamental elements of scientific argumentation, including claim, evidence, and warrants (Driver, Newton, & Osborne, 2000). Recently, scholars have argued that the teaching of argumentation should be included in the science curriculum in more overt ways (Driver, Newton, & Osborne, 2000). Argumentation is an essential characteristic of the scientific enterprise; that which is unique to science as a way of knowing is captured in the literary form of the scientific argument. It is only through engagement in hearing, writing, or reading an argument that a learner will become most familiar with those reasoning forms that are particular to science, including questioning, interpreting data, making claims, and providing evidence for those claims. A thorough understanding of argumentation will form the foundation for problem solving in everyday life (Kuhn, 1993).

A third important component of science learning is metacognition (Pintrich, 2002). It has become widely recognized that students need to develop metacognitive knowledge in order to be effective learners. Metacognition involves monitoring one’s own learning and making necessary modifications to cognitive actions (Butler & Winne, 1995). Pintrich (2002) summarized current research on metacognition as having three major elements. The first type, strategic knowledge, is knowledge of general thinking skills to facilitate learning and problem solving. Strategic knowledge includes rehearsal, organizational, and elaboration processes that learners use across different topical domains. By employing strategic metacognitive knowledge, for example, organizing and elaborating information about a chemistry problem, learners can make connections and promote their own knowledge construction. The second type, knowledge about cognitive tasks, reflects an individual’s understanding of when and how to apply various strategies. For example, over a period of years, learners come to understand the demands of writing tasks, such as persuasive essay, that enable them to compose more readily. Third, self-knowledge, involves a knowledge of one’s own strengths and weaknesses, and one’s own motivational state. Self-knowledge is important for planning and monitoring learning activities.

Meaningful construction of knowledge during both reading and writing depends largely on metacognition (Holliday, Yore, & Alvermann, 1994; Keys, 1999), making it essential for scientific literacy. Strong readers apply a knowledge of their own strengths and weaknesses to organize prior knowledge and new information and to elaborate on text ideas while reading (Holliday, Yore, & Alvermann, 1994). Strong writers consistently judge the fit between the content they are trying to express and the language they are using to represent that content. Searching for language during writing can stimulate some writers to further search for and elaborate content. Metacognition is also necessary for the construction of a scientific argument in that the learner must monitor and evaluate the fit among the logical parts of the argument, for example, the fit between claims and evidence. Pintrich (2002) suggested that teachers explicitly teach metacognition infused into content. The teaching of metacognition is most closely linked to the second construct of the theoretical framework described in this paper, multiple discourses, as I describe below. Thus, the framework below assumes that to be scientifically literate, a learner must be able to effectively read and write scientific texts, be a metacognitive thinker, and be able to construct the elements of a scientific argument.
THREE CONSTRUCTS FORM THE THEORETICAL FRAMEWORK

Authenticity in Scientific Language Use

While the construct of authenticity has often been referred to in the science education literature, its significance in the learning process has remained obscure. Doyle (2000) illuminated and critiqued the concept of authentic curriculum. He described three versions or forms of authenticity: (a) child-centered authenticity, in which the learning is designed to be within the personal meaning and experiences of the child, and for which the enemy is adult understandings that consider children’s understandings to be deficient; (b) subject matter authenticity, in which the learning is designed to align with the work of professionals in the discipline (e.g. scientists) and for which the enemy is predigested versions of content in textbooks; and (c) situated authenticity, in which learning is centered in real world activity and for which the enemy is knowledge decontextualized from situations in which it is used or experienced. While Doyle sees value in promoting all three versions of authenticity, he cautions that because school cannot be the real world, all content must be interpreted for teaching. The role of the teacher is to transform the subject matter into forms that represent authentic meaning to the child. Doyle, drawing on Dewey, asserts that the tension between discipline-based or situated subject matter and the child’s personal interests provides a foundation for the curriculum with the teacher utilizing the resources of each. Dewey (1902) postulated that child-centered interests and subject-matter structure form two endpoints of a dynamic continuum for designing curriculum. A school curriculum, such as science, must be located somewhere between these two endpoints and is continually reconstructed as it moves back and forward along the continuum. He explains:

Abandon the notion of subject-matter as something fixed and ready-made in itself, outside the child’s experience; cease thinking of the child’s experience as also something hard and fast; see it as something fluid, embryonic, vital; and we realize that the child and the curriculum are simply two limits which define a single process. Just as two points define a straight line, so the present standpoint of the child and the facts and truths of studies define instruction. It is continuous reconstruction, moving from the child’s present experience out into that represented by the organized bodies of truth that we call studies. (Dewey, 1902, p. 11)

These ideas can be readily applied to the issue of learning to use scientific language authentically. While the child brings his own socio-cultural language to the science classroom, science as a discipline brings a specialized language with particular functions (Halliday & Martin, 1993). Thus, we may view authenticity of language use as the transformation of language between the frames of child-centered authenticity and subject matter (or perhaps situated) authenticity. Successful learning within this context will mean, then, that the child is using scientific language to communicate about personally meaningful science events. When the child needs to use scientific language to express her own experiences, she will be authentically communicating. The authentic use of language will involve the appropriation of academic scientific discourse into everyday language. It follows that the more the child’s everyday experiences mirror the experiences of those who use academic science (scientists), the higher will be the appropriation of scientific language into authentic communication.

The idea of successful science learning as using scientific language to communicate personally meaningful science events was illustrated by a teacher in one of my research studies. When asked to characterize successful science learning, Ellen, a veteran high school biology teacher, replied:
I think when I see students using scientific vocabulary, using process skills, like it was the most natural thing in the world. Like they’re really not even thinking about it any more, like it’s just been incorporated into their problem solving skills. That’s when you have a really successful activity. If they’re telling me “that thing over there” or “I don’t exactly know what we did here,” constantly referring back to their notes, I think we have a problem here. I think they’re telling me right there that they didn’t learn too much from that activity...but I found in particular in the herb lab that they were using many terms, like they would use any other common term- like they would use “pencil.” They were coming up with “where are my aliquots” or “there’s something wrong with my agar.” I think that has to do with success, when a kid can explain it back to you or, and this is a big one- when they can take what they learned and apply it in a similar situation. (Ellen interview, 4/27/01)

In Ellen’s classroom, students are using phrases like, “where are my aliquots” because they have an authentic need to condense their vocabulary into specialized forms. Talking about aliquots has become a sociocultural practice in Ellen’s classroom. We may speculate that students in Ellen’s science class see meaning in the herbal antibiotic activity and are therefore purposefully engaged. This type of engagement is key to authentic language use (Hand et al., 2003). Scholars of language and literacy have been researching student engagement with literacy in out of school activities (e.g. video games) to help determine what task features facilitate authentic and meaningful literacy engagement. For example, giving students choice in how to express their literacy has been found to increase engagement with the task (Hand et al., 2003). Examples like these illustrate the usefulness of considering curriculum as a fluid movement between the child’s experience and interests and subject-matter knowledge, as articulated by Dewey (1902).

Some scholars (Ballenger, 1997) have argued for the use of vernacular language in the science classroom as a way to promote authentic science literacy. Ballenger (1997) found that when Haitian–Creole students engaged in vernacular discussions about mold, both scientific discourse styles in the forms of claims and evidence, as well as nonscientific discourse styles, such as moral stories, developed. She asserts that the cultivation of vernacular language use in science class can lead to rich thinking about science and represent less threatening forms of instruction for students of nonmainstream sociocultural backgrounds. Vernacular language is certainly authentic to children and is the obligatory starting place for appropriating scientific language use. However, I agree with Gee (Gee, 2001, 2002; Hand et al., 2003) that students who engage in scientific discourse forms will form more powerful understandings of the nature and uses of science. Gee suggests that at some point in discourse, the specificity of scientific language promotes further processing of scientific ideas (Hand et al., 2003). He (Gee, 2002) posits that there is no such entity as “decontextualized language,” and that former arguments that White middle-class children can deal with decontextualized language better than other sociocultural groups are flawed. Scientific language is meaningful only when used in authentic contexts; students who have difficulty communicating in academic genres may not have had sufficient experiences in school to foster their authentic use of scientific language. Gee (2002) asserts that it is the job of schools to generate rich scientific cultures in the classroom, so that students have a need and a purpose for communicating in scientific discourses.

Gee’s (2001) assumptions about authentic learning of academic discourses include: (a) the ability to cope with academic language is essential to successful participation in school; (b) acquiring an academic language, such as science, requires the learner to accept the losses involved in using everyday language, and perceive the gains of using academic language; (c) a social language is only useful when it is embodied in experiences; (d) language acquisition involves access to and simulations of perspectives of advanced users of the language; (e)
lifeworld language is problematic for science; and (f) face to face conversation is insufficient for the acquisition of scientific academic language. These claims form the basis for a new authenticity of language use as learners struggle to make sense of scientific discourse. They imply that students should have multiple opportunities for doing science and talking about science with both inexperienced and advanced users of scientific language.

Students’ epistemologies in terms of their learning beliefs will also play a role in the way they view information available to them and subsequently the way they will appropriate words and concepts into their repertoire (Butler & Winne, 1995). Research has indicated that students with more constructivist learning beliefs and nature of science understandings, including the idea that science knowledge is created by people rather than uncovered from nature, may be better able to learn from laboratory activities, talk, reading, and writing (Edmonson & Novak, 1993; Tsai, 1999; Wallace et al., 2003). This may be due to believing that they have the epistemological power to create their own questions, connections, and knowledge claims. In contrast, those who believe that science is a body of correct knowledge to be learned may feel disempowered to create their own scientific ideas. The construct of students’ epistemologies may interact with the way students will appropriate scientific language authentically for their own use.

The appropriation of scientific discourse is necessary for a full and powerful construction of scientific literacy. However, this appropriation must be authentic and based in reading and writing, as well as talk. Learners need to use the language, as Gee suggests, when it is embodied in experience. They also need access to communication with other authentic users, including peers, scientists, or the classroom teacher. They must gain an authentic desire to use the language—i.e. they must have something important to say. An authentic use of scientific language is necessary for reading and writing scientific texts, as well as constructing a scientific argument. Therefore the first element of the framework, authenticity, implies that in order to become scientifically literate, learners must appropriate academic scientific language into their own forms of communication.

Multiple Discourses

The second construct in the framework, multiple discourses, suggests that there are several types or genres of scientific language at work in the classroom. Casual peer group discussion or “benchwork” talk differs from the language used in a group presentation to the class, a summary paragraph written by a student, a lecture given by the teacher, or the reports printed in a textbook (Mark Templin, personal communication, 1/2002). These distinct genres each have their own epistemological foundation, in other words, what counts as sources of knowledge and degrees of certainty ranges widely among these genres. For example, reports found in a textbook are based on well established theory that has won the approval of the community of scientists (indeed, they are often presented as fact). Claims made by a student group about the results of their experiment have a different epistemological foundation; they are very tentative and localized claims. The epistemological foundations of many other genres, such as a demonstration performed in a video or a newspaper article are intermediate. Further, some genres of scientific information, such as articles found on the Internet carry an unknown epistemological foundation (Goldman & Wiley, 2002).

Most often, these various forms of discourse are encountered in a daily science class without any explication of their differences. Typically, we have not taught students to recognize various discourse genres nor to critique their epistemological basis. Research shows, however, that student learning can be sensitive to the sources of knowledge on which they rely. Some learners have no trouble integrating various knowledge sources, such as their own data from lab activities with authoritative sources. Other students rely
almost exclusively on their first hand observations, and yet others will incorporate only authoritative explanations from their teacher or textbook into their belief systems (Wallace, 2004). The use of a range of discourse styles is characteristic of all human interactions and is reflected in the communication of scientists. However, because students are just learning the language of science, differentiating among these discourse types may be problematic.

Moje, Cozollo, Carillo, and Marx (2001) point out four characteristics of classroom interaction necessary for promoting diverse students’ authentic scientific literacy: (a) drawing on students’ everyday discourses and knowledges; (b) developing students’ awareness of those discourses and knowledges; (c) connecting those everyday discourses with those of scientific genres; and (d) negotiating among these disparate discourses for scientific sense making. Most students will not be familiar with the academic discourse style of scientific genres (Gee, 2001). For example, one of my colleagues explains how she taught a student to translate between a cultural language, which they called “Southern” and the academic language that the student needed to pass a standardized test, which they called “School.” Usually, school genres, including scientific ones, are used without explicit instruction in how to interpret them. Moje and colleagues’ (2001) suggestion to develop students’ awareness of their everyday discourses, science discourses, and the need to negotiate among them could facilitate a more authentic use of scientific language.

The explicit teaching of metacognitive knowledge (Pintrich, 2002), along with science content, could provide students opportunities to unpack different discourse genres. For example, instruction about the cognitive tasks required to read a scientific text could teach students general strategies such as, evoking prior knowledge, questioning new information, and connecting new information to prior knowledge. Reading instruction could help students recognize the claims and evidence presented in text, as well as, judge the certainty of discourse (Norris & Phillips, 2003). Open discussion about how informal laboratory talk or writing compares to more formalized forms of communication, such as a presentation poster, could elucidate discourse styles and help students locate their own speech into various discourses.

Writing instruction is a promising vehicle for introducing students to different discourse styles. Different types of language use are required when writing to different audiences. Research by Hand and colleagues (Hand et al., 1999; Hand, Wallace, & Yang, 2004; Prain & Hand, 1996) has indicated that transforming scientific language for an audience other than the teacher promotes both greater conceptual understanding of the content and a greater understanding of different discourse styles when communicating in science.

In these research studies, we interviewed students about their perceived benefits of writing for an audience other than the teachers. Students from grades 7 to 11 repeatedly articulated the understanding that the teacher already has an in-depth knowledge about the content, and so they could use terms and explanations in more of a rote manner, without their own complete understanding, and still be confident that it would make sense to the teacher. When writing for a different audience, the scientific language needed to be unpacked and explained using more everyday language. This activity of unpacking the language triggered metacognitive thinking on the part of the students, as they were required to verbalize their thoughts in more than one language representation. The quotes from children below illustrate their understandings of (a) the teacher’s knowledge; and (b) the need to use transformed language for an audience unfamiliar with the scientific domain.

... we wrote to somebody else instead of Mr. M. and so you had to put your ideas in a different way so that someone your age who hasn’t studied it could understand it... I think I had to put a little bit more effort in it because Mr. M. was studying the thing with us and he was teaching us so he knew what we were trying to say and when you’re writing
to someone who doesn’t understand anything you have to go into really specific details for them to understand. (girl, grade 7)

It is harder to write for another person than a teacher because it’s another person your age and you have to speak their way, whereas the teacher will accept any sort of words. (boy, grade 9)

The vocabulary [for a younger audience] has to be a lot easier to understand. When you are writing to a teacher, they already know what the stuff means. You are not trying to tell them what they [the words] mean; you are just trying to use them to tell that teacher that you know what they mean. (boy, grade 11)

The quotes above indicate that children in school science are fully capable of understanding the occurrence and features of different discourse styles, but that they need experience in transforming language from one discourse style to another. I assert that unpacking the various discourse genres used in science class will contribute to the authentic use and understanding of academic science language by students. Through such knowledge of multiple discourses, they will be able to read, write, and argue with a greater language facility. Thus, the second element of the framework, multiple discourses, implies that in order to become scientifically literate, learners need to recognize multiple discourse genres and learn to negotiate among them.

Bhabha’s Third Space

The third piece of the theoretical framework is acquired from Homi Bhabha’s notion of the Third Space. Bhabha is a postcolonial political theorist with an emphasis on the role of culture and language in interactions. While a keen observer of alienation and political opposition, such as those involved in colonial oppression, Bhabha suggests that opponents move beyond the establishment of positions and identities, using narratives to find innovative spaces for communication. He states (Bhabha, 1994, p. 1) “What is theoretically innovative, and politically crucial is the need to think beyond narratives of originary and initial subjectivities and to focus on those moments or processes that are produced in the articulation of cultural differences.” These moments of articulation or “in-between spaces” (Bhabha, 1994, p. 1) provide a zone for new interpretations of meaning. Bhabha is concerned with political hegemony of that type which might be represented by Euro-centered science in the classroom or authoritative discourses of the teacher or textbook. By creating “in-between spaces,” he insists that the hegemonic interpretations can be viewed as not necessarily “correct” or “true.” He describes communication as follows:

The pact of interpretation is never simply an act of communication between the I and the You designated in the statement. The production of meaning requires that these two places be mobilized in the passage through a Third Space, which represents both the general conditions of language and the specific implication of the utterance in a performative and institutional strategy of which it cannot be conscious. What this unconscious relation introduces is an ambivalence in the act of interpretation. The pronominal I of the proposition cannot be made to address—in its own words—the subject of enunciation, for this is not personable, but remains a spatial relation with the schemata and strategies of the discourse. The meaning of the utterance is quite literally neither one nor the other. (Bhabha, 1994, p. 36)

My interpretation of this passage in the context of using language to learn science is that the meaning of an utterance is neither precisely the meaning of the speaker (the I) nor the meaning of the listener/interpreter (the You). The spatial relation referred to by Bhabha
might be considered a metaphor for the required distance placed between the meaning of
the speaker and the meaning of the listener. Neither can have the personal interpretation
of the other due to the constructivist features of experience. However, both are bound by
frames such as syntax and vocabulary, “the general conditions of the language” and are tied
to normed views of meaning. Thus, there is an ambivalence generated around the meaning
of the utterance. The Third Space, then, is an abstraction of a space/time location in which
neither the speaker’s meaning nor the listener’s meaning is the “correct” meaning, but in
which the meaning of the utterance is hopeful for either co-construction of interpretation
or new hybrid meanings.

In the science classroom, the implication is that neither the teacher’s meaning, nor the
student’s meaning for an utterance is the correct meaning, but that learning will involve
the negotiation (here in the sense of cooperation or compromise) of meaning until either
there is mutuality of meaning, or a new hybrid meaning is constructed. These ideas seem
to be very closely related to Osborne and Wittrock’s (1983) notion of generative learning,
in which a learner will receive sensory input and generate new meaning in light of prior
knowledge. However, what Bhabha’s theory contributes is the elimination of cultural hege-
mony in communication. Because language must travel through the Third Space, neither
the speaker’s nor the listener’s state of understanding is privileged.

For example, in the well-known video, A Private Universe, the ninth grade student, Heather, has a different meaning for the term “indirect” rays than the researcher. Bhabha’s
Third Space interpretation of this incident might be that neither the researcher’s under-
standing of indirect rays, nor Heather’s is the “true” meaning, although scientists have a
consensual understanding of this term that in general agreement with the researcher. The
meaning of the word “indirect” in the communication between Heather and the researcher
remains in the Third Space—it is ambivalent. Heather’s idea of “indirect” is a representation
of her current science culture.

Thus, we may interpret the Third Space as an area in which neither one of two differ-
ent languages are dominant, but the meaning of both may be transformed according to
new experiences. An understanding of the Third Space construct aids us in thinking about
students’ meanings for scientific phenomena and links to authenticity in a very critical
way. We are compelled to accept children’s authentic understandings, even if they are not
in accord with scientific authority. However, through dialogue with children, as Bhabha
suggests, we may be able to construct hybrid meanings. In the Third Space, multiple dis-
courses may be woven together without sacrificing or dismissing the importance of their
speakers’ experiences and ways of knowing the world. Drawing from the concept of the
Third Space, Gutierrez et al. (1999) suggest that the official script and learner script could
be made to converge in meaningful authentic ways to form rich zones of collaboration and
learning.

How do students in the science classroom attempt to move through the Third Space? One
example comes from the written discourse of tenth grade biology students at a rural high
school in the Southeastern United States. These students were asked to create explanations
for their observations of a simple laboratory activity, water movement into and out of an
egg. Most science educators will be familiar with this demonstration in which a raw egg is
first allowed to soak in vinegar to remove the shell, then immersed in a sugar syrup, where it
shrinks, and then into distilled water, where it swells greatly. The teachers/researchers had
students conduct this activity in groups, then write their claims, evidence for their claims,
and their explanations on a laboratory worksheet. The students were encouraged to use any
of the theoretical principles they had learned previously in a lecture on osmosis or from
their textbooks. However, they were also encouraged to use their own authentic voice and
their own words to compose their explanations.
A content analysis of the students’ written data revealed that there were two basic approaches to writing the explanation. In approximately half of the 14 written documents examined, students adopted an academic scientific discourse style with a generally correct, although almost always partial, explanation of the osmosis phenomenon. For example, one student wrote,

*If the pressure inside the egg is less than the pressure outside the egg, water will move in like when put in water—hypotonic. If the pressure inside the egg is more than the pressure outside, water will move out like when put in the syrup—hypertonic.*

I speculate that these children could “see” the egg activity in the same way that a scientist might. However, in the other half of the documents, students invented their own explanations, using both everyday and scientific terms to construct their explanations. Another student wrote,

*I think the vinegar began pickling the raw egg making it absorb the water. Then the syrup caused the egg to push out the water due to the pressure of the syrup. When in water, the egg reabsorbed the water. Diffusion is when a cell allows more than water to pass over the cell membrane. For instance, when you place an egg in syrup after vinegar overnight, the egg absorbs a little syrup causing the egg to become tough.*

This student clearly entered the Third Space in an effort to explain her investigation results. She attempts to blend authoritative language with her own meaning, for example, she has learned that diffusion is movement of molecules, and this has been distinguished from osmosis for the movement of water molecules, “diffusion is when a cell allows more than water to pass over a cell membrane.” She can explain her observations of the egg adequately with the nonscientific idea that the pressure of the syrup pushed on the egg and some of the syrup diffused into the egg, making it tough. At this point in time, she cannot authentically adopt the scientific meaning for the language of osmosis.

Students in the study described above did not have the opportunity to design their own investigation questions. It may be that when students are engaged in more open-ended or inquiry-based laboratories, they will use scientific discourse more readily. In 2001, we analyzed the written discourse of several students who were engaged in inquiry-based nonmajor college biology lab (Wallace & Narayan, 2002). The study probed whether students immersed in what we believed to be authentic and situated science learning would adopt features of academic scientific discourse. While results varied among the students, one student in particular, Brittany, who also exhibited a constructivist epistemology, indicated that she had appropriated the academic language of science into her written explanations for laboratory results. Some indicators of a scientific discourse style included her frequent use of cause/effect words and grammatical metaphors (processes and/or actions condensed into nouns, e.g. photosynthesis; Halliday & Martin, 1993). In her lab reports, Brittany created claims about her data and proposed meaningful explanations for her findings. In the case of her first laboratory report, Brittany was attempting to explain her unexpected results for the inhibition of bacteria, while in the second, she was explaining biological interactions in a simulated ecosystem.

*The bacteria growth did not occur as originally thought. Nitrate was not increasing the bacteria growth, but instead it was inhibiting it. Did something go wrong? No, but bacteria will live and thrive from nitrate only under anaerobic conditions . . . The agar plates are considered to be an aerobic environment; therefore, NO₃ was killing off the bacteria,*
because it could not get the nutrients it needed in order to grow. When first choosing this experiment, the type of environment was not considered. This was a very important factor that was overlooked… (Brittany, experiment report)

...The turbidity went through many stages, but ended up very close to where it had started. The plant did grow significantly, and algae took over most of the space in the jar. The fish died off slowly, and as a result, the nitrate levels never increased. The plant and algae growth had a significant effect on the rise of the DO levels and the constant result of zero for nitrate and phosphorus…. (Brittany, aquajar report)

Brittany synthesized new information to create an explanation for her anomalous laboratory results in the first excerpt above. She claimed that the addition of nitrate was inhibiting bacterial growth, as supported by her data, then explained that the addition of nitrogen would only be expected to enhance bacterial growth under anaerobic conditions. In the second excerpt, she used scientific language to make firm claims, such as, “the plant and algae growth had a significant effect on the rise of the DO levels,” that were supported by data in the results section. She also synthesized her claims with explanations, for example, “The fish died off slowly, and as a result, the nitrate levels never increased.” Here she was explaining the consistent finding of small levels of nitrates in the jar from week to week with reference to the small amount of organic matter decomposing in the jar.

Brittany’s facility with making claims and explanations, as well as her relatively strong use of grammatical metaphors indicate her willingness to engage in scientific discourse. She entered into authentic dialogue about her inquiry activities and she negotiated the multiple discourses surrounding her laboratory experiences, including textbook and Internet resources, discussions with her laboratory instructor, and informal discussions with her lab partner. When reading and hearing about how nitrogen promotes bacterial growth only under anaerobic conditions, Brittany’s meaning for the addition of nitrogen (originally she expected to find increased bacterial growth) and the scientific meaning for the addition of nitrogen (only under anaerobic conditions) both passed through the Third Space and became transformed for Brittany into the language of the culture of science. This example illustrates the need for science learners to engage the Third Space as they attempt to read and write scientific texts and engage in scientific argumentation. The third element of the framework, Third Space, implies that in order to become scientifically literate, learners must be willing to enter the Third Space and collaborate in the construction of scientific meaning.

FORMULATION OF A MODEL

Figure 1 indicates a model constructed to link the ideas expressed above into a coherent theoretical framework. The basic shape of the model is a triangle with the key constructs of authenticity, multiple discourses, and the Third Space located at each point. This arrangement provides links between the three constructs, as well as, a focal point for each. Potentially, many conceptual links can be made among the three constructs. The two that I find most important are (1) there is a close connection between authenticity and the Third Space—only authentic communications will be of use when learners negotiate the Third Space and considerations of meaning in the Third Space will depend on learners attempting to appropriate scientific language into their meaning networks; (2) there is a close connection between multiple discourses and the Third Space with the I and the You participants paralleling private and public discourse genres; an individual’s meaning in a personal, private sense must be transformed across genres into more public forms in order for Third Space negotiations to take place.
Each of the key constructs can further be represented by a continuum with hypothetical endpoints that bisect the triangle. In the first dimension, authenticity, the continuum is represented by the term expression to indicate that learners will (and should) express themselves in authentic ways using language from vernacular to scientific. Points along the continuum (from left to right) would represent the gradual incorporation of more scientific vocabulary, syntax, functional grammatical elements, and so on into a student’s written and verbal expression. An example of the endpoint for scientific language might be that used in a scientific journal article.

In the second dimension, multiple discourses, the continuum is represented by the term voice to indicate that discourses range from private genres of speculation and questioning to public genres of evidence-based science that has the authoritative voice of the scientific community. Thus, the endpoints of the second continuum are private and public. Private discourse genres might include descriptions, questions, and observations raised in between children in the classroom. These private discourse genres might include vernacular language, such as the mold stories told in Ballenger’s (1997) study. Public discourse genres at their extremity would be typified by science textbooks that use a language of certainty to explain and describe scientific phenomena for the masses. Points along the continuum might represent a range of discourse styles found in the classroom or in the general media, such as, peer group discussion, journal writing, student presentation, or Internet report.

In the third dimension, the Third Space, hypothetical endpoints are represented by I and You, signifying the personal and individual construction of language between two participants in a discourse. The term representing the continuum for the Third Space is meaning, emphasizing the semiotic dimension of language use (Halliday & Martin, 1993). Points along the continuum would represent hybrid meanings for scientific words and events, such as understandings of the term “animal” ranging from a naive perception of only mammals to a detailed scientific classification scheme for the animal kingdom. Artifacts representing
meaning in the classroom would include a wide range of verbal and written discourses that could be probed by the students and teacher for the unpacking of mutual meanings.

**REFLECTIONS ON THE MEANING OF THE MODEL FOR RESEARCH**

Application of this theoretical framework suggests that research programs focus on classroom instruction where authentic language use, unpacking of multiple discourses, and negotiations through the Third Space are occurring. While explorations of classrooms in which vernacular language is used to make meaning of science (Ballenger, 1997) are necessary, there is also a need for long term, in-depth studies of students’ gradual appropriation of academic science language. Under what conditions do students most readily appropriate scientific language? Are experiences doing science the only necessary factor for such appropriation? How do reading and writing practices influence the appropriation? Do students see value in the appropriation? How does the appropriation interact with students meaningful understandings of science as located in the Third Space?

Studies of unpacking multiple discourses used in science might begin with a more focused research agenda on the explicit teaching of reading in science class. Strategies for determining the epistemological stance of the text (e.g. the certainty status), as well as, the basic meaning of the text could be applied. Many existing tools, such as the reciprocal teaching model (Brown & Palinscar, 1989) could be adapted for these purposes. Additionally, explicit teaching of metacognitive strategies used in reading and writing could be implemented in science class (Pintrich, 2002). A complementary line of research would focus on the teaching of writing in a science context. Learners could produce journals, group writing, public presentations, textbooks for younger children, etc., while parallel discussion probes the differences in genres for these different audiences. Tests and measures of reading and writing a variety of genres, including argumentation, need to be further developed and used. Questions such as the following might be investigated. What reading strategies and activities are most efficacious for promoting scientific literacy? How does the explicit teaching of reading and writing in science impact “low achievers” communication skills and conceptual understanding? How readily can students recognize and make sense of different discourse genres? How readily can students adapt and use genres for their own authentic communication?

The third arena of research is that suggested by the Third Space construct. For the most part, this arena is already well-researched in the conceptual change literature. We have known for the past two decades that children bring their own meanings to science language and develop conceptual knowledge structures based on those meanings (Osborne & Freyberg, 1985). I believe that Bhabha’s idea illuminates this research base in the following way: The goals of the science education curriculum should include engaging with ideas in the Third Space, in addition to achieving target conceptual understandings at any particular point in time. This idea is foreign to most science teachers and is not clearly articulated in current reform documents, such as *The National Science Education Standards* (National Research Council, 1996), which include content objectives. The issue is not one of the devaluation of traditional science concepts, conversely, it is valuing them so highly that we would want students to integrate them into their knowledge bases in only authentic, meaningful, and useful ways. For example, in the scenario described above where tenth grade rural biology students wrote explanations for osmosis through an egg, incorrect but logical explanations could be accepted as readily as correct ones with the astute teacher looking for further opportunities to help students view the situation through the scientific lens. Such a research program might have an agenda toward shaping science education policy.
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REFERENCES


