Science
Education

Language, Access, and Power in the Elementary Science Classroom

EMILY SCHOERNING,[1] BRIAN HAND,[1] MACK SHELLEY,[2]
WILLIAM THERRIEN[1]
[1]*Department of Teaching and Learning, University of Iowa, Iowa City, IA 52240, USA;* [2]*Department of Statistics and Department of Political Science, Iowa State University, Ames, IA 50010, USA*

Received 20 December 2013; accepted 10 October 2014
DOI 10.1002/sce.21154
Published online 18 February 2015 in Wiley Online Library (wileyonlinelibrary.com).

ABSTRACT: The Next Generation Science Standards call for the adoption of many aspects of scientific inquiry in the classroom. The ways in which classroom talk and classroom environment change as students and teachers learn to utilize inquiry approaches are underexplored. This study examines the frequency with which linguistic markers related to access and power appear in student and teacher speech in the elementary science classroom. As teachers begin to implement argument-based inquiry methods, teacher and student use of these markers changes significantly. These changes indicate that students whose teachers utilize argument-based inquiry have greater access and power in the science classroom. In this paper, the mechanisms by which teachers afford their students access and power are explored from a quantitative perspective. *Sci Ed* **99:**238–259, 2015

INTRODUCTION

The Next Generation Science Standards (NGSS) require that students pose questions, design activities to generate data, and construct claims based on evidence (NGSS Lead States, 2013). Accordingly, one of the critical features of the NGSS is argumentative reasoning. This means that evaluating and understanding approaches to science teaching and learning that emphasize the acquisition of this form of reasoning are of growing national importance. While there have been a number of approaches proposed to address argumentative reasoning, Cavagnetto (2010) highlights immersion approaches as being

Correspondence to: Emily Schoerning; e-mail: emily-schoerning@uiowa.edu

of critical importance. In these approaches, efforts are made to teach science as science is practiced, meaning that students must engage in the practices of science, such as the construction and critique of arguments that support explanations of how the world works.

The Science Writing Heuristic (SWH) approach is an immersion approach to argument-based inquiry, which is closely aligned to the NGSS (Choi, Notebaert, Diaz, & Hand, 2010; Hand, Norton-Meier, Staker, & Bintz, 2009; Norton-Meier, Hand, Hockenberry, & Wise, 2008). Under this approach, students develop questions, design experiments, gather data, and generate evidence to support claims that address their initial questions. The SWH does not utilize set curricula. Under the SWH approach, students and teachers follow templates that guide them in scientific investigation. When beginning a new unit, the teacher introduces a topic, such as the water cycle. Students are encouraged to ask questions about this topic in an initial brainstorming session. The teacher records these questions, and together the teacher and students choose several questions to further explore. Students work to further define the questions they generated, then begin to design experiments that will allow them to answer these questions. Teachers provide assistance in this process in the form of questioning, encouraging dialog, and providing guidance and access to resources. Under the SWH approach, teachers rarely provide direct, factual answers to student questions. The goal of the SWH teacher is to develop a classroom environment wherein students can acquire and develop the skills necessary to answer their own questions.

Once students design their own experiments they perform the experiments and gather data. Teams of students work to analyze these data and develop claims and evidence. Teachers explicitly instruct students in how to construct these scientific arguments. The students' experiments should address a question and allow them to support a claim based on evidence. Students construct these "question–claim–evidence" arguments in their teams, then present their findings and arguments to the class. Different teams ask questions of each other as they work to construct and critique their arguments and understandings related to the research topic at hand.

The SWH approach is just one immersion approach to inquiry science teaching and learning. The SWH approach was utilized in this study due to previous work establishing its utility in facilitating student–student dialog and argumentation (Akkus, Gunel, & Hand, 2007; Choi et al., 2010; Hand et al., 2009; Norton-Meier et al., 2008; Schoerning & Hand, 2012, 2013). Additionally, the SWH approach has recently been evaluated in the context of a statewide randomized control trial, which examined the effects of the treatment on elementary school students in Grades 3–5. Results show that students exposed to the SWH experienced significantly greater rates of growth on state standardized tests in subjects including math, reading, and science, with greater rates of growth also seen on tests of critical-thinking skills. Exposure to the SWH was found to narrow achievement gaps between male and female students. The treatment had particularly strong positive effects on underserved demographic groups, such as students receiving free and reduced lunch, Black and Hispanic students (Hand, Therrien, & Shelley, 2014; Hand, Therrien, Shelley, & Laugerman, 2014; Laugerman et al., 2013).

Although there is research-based evidence that the SWH is an effective approach to immersion science instruction, it is just one approach to science teaching and learning, with both known strengths and potential weaknesses. The SWH approach, with its strong student-driven focus, may result in students acquiring less content knowledge than more structured or scaffolded immersion approaches to science teaching and learning. Owing to the fact that the SWH approach does not rely on a set curriculum, this approach can also be challenging for teachers to implement, as it relies on their development of a strong and flexible skillset including both pedagogical practices and content knowledge. This study will reference the SWH rather than immersion practices in general, as those schools

participating in the study were being explicitly instructed in the SWH approach. However, it is reasonable to infer that results from this study may also apply to other immersion-based approaches to science instruction that are aligned to the NGSS and focus on argumentation.

While research related to the SWH approach does indicate the approach has significant benefits for students, viewing these findings from a purely statistical perspective does not allow us to understand how and why the SWH approach provides students with opportunities for success. The SWH approach heavily utilizes many forms of language, both in terms of student writing and as related to the essentially dialogic nature of its classroom environment. However, as Moje, Collazo, Carrillo, and Marx (2001) highlight, dialog and student–student talk are rare in traditional science classrooms. Because of the importance of dialog in the SWH classroom, there are particular requirements for SWH learning environments; in contrast to traditional science classrooms, SWH students must have access to agency and power to openly and fully participate in a truly dialogic classroom. This study seeks to examine and describe how students' and teachers' use of spoken language changes as classrooms implement the SWH approach, with the goals of beginning to unpack how SWH classrooms afford students opportunities for academic growth and success, and of understanding how student agency and power may shift as students are afforded opportunities for dialogic expression.

The SWH approach to argument-based inquiry focuses on both enabling negotiation and developing an understanding that scientific argumentation is a particular form of negotiation framed by the discipline of science (Chen, Hand, & McDowell, 2013). Negotiation as seen here is defined as the skillful overcoming of obstacles (Reznitskaya & Gregory, 2013), and encompasses a complex set of linguistic tools. Accordingly, the use of the term negotiation has significant potential value for the field of science education, including as it does a variety of ways of communicating beyond but related to scientific argumentation by enfolding the concepts of dialog and problem solving in a larger sense. However, exploration of what negotiation means in the context of the science classroom is currently lacking in the science education literature.

Negotiation

Useful work related to the concept of negotiation has been accomplished in the field of business, where various aspects of negotiation have been explored, with four main aspects being defined (Cobb, 2000). In negotiation, one diagnoses problems, structures deals, fosters the participation of stakeholders, and builds consensus (Dukes, 1996; Fisher, Ury, & Patton, 1991; Lax & Sebenius, 1986; Raiffa, 1982; Susskind, McKearnan, & Thomas-Larmer, 1999). These aspects have clear parallels to the science classroom standards and practices described in the NGSS, where it is desired that students should learn to identify problems, find solutions, and build consensus through the discipline-specific norms of scientific argumentation. These three aspects of negotiation have been somewhat addressed in the science education literature through the lens of language and argumentation.

Argumentation has previously been described as the means of scientific discourse (Lemke, 1990), and thus argumentation can be considered a language of science (Duschl, Ellenbogan, & Erduran, 1999; Tippett, 2009). Research has found that argument enhances students' understanding of scientific concepts, that it improves their understanding of the science process, and that it encourages the development of critical thinking skills by making their thinking processes more transparent (Abi-El-Mona & Abd-El-Khalick, 2006; Crawford, Zembal-Saul, Munford, & Friedrichsen, 2005; Jiménez-Aleixandre, 2007; Zembal-Saul, Munford, Crawford, Friedrichsen, & Land, 2002). Mastering the language of argumentation is considered a key aspect of developing scientific literacy (Cavagnetto, 2010).

The fourth aspect of negotiation, fostering the participation of stakeholders, while less explored, has particular resonance when we apply negotiation to the language of the science classroom. A goal of science education is to transform students into stakeholders; considerable research in the field has focused on increasing student motivation, and successful approaches to inquiry teaching and learning tend to stress the degree to which students become actively involved in science learning and the science process (Sevinc, 2011; Tuan, 2005). Research in these areas seems compatible with, but not analogous to, work in this fourth aspect of negotiation, in good part because current research does not address the degree to which negotiation is a language-based process.

The SWH approach focuses on enabling all four aspects of negotiation. Researchers have done considerable work to understand how the argumentative aspects of negotiation impact students in SWH classrooms through both written and spoken language (Akkus et al. 2007; Choi et al., 2010; Creedy & Hand, 1994; Martin & Hand, 2009). This study examined features of negotiation related to the fourth aspect—fostering participation and creating stakeholders. We recognize that power and access change once negotiation is enabled in a classroom. However, we have not fully unpacked the concept of negotiation as it relates to access and power, and thus do not fully understand the mechanisms by which negotiation might afford opportunities for student access and achievement.

Student Access

If students are to have their ideas respected in the classroom, they have a need for access and equity. Once they possess these, their ability to express ideas in the classroom is an expression of power. In traditional science classrooms, students do not possess power, while teachers do so unambiguously. Power here is seen both as authority, in that the teacher has the ability to direct the actions of others in the classroom, and as ability, in that the teacher maintains, distributes, and evaluates knowledge (Goodman, Hoadland, Pierre-Toussaint, Rodriguez, & Sanabria, 2011). Power as described here is not strictly dichotomous, being necessarily lost by one group as it is gained by another, but as something that arises and circulates within populations in the Foucauldian sense, as described in Lewis, Enciso, and Moje (2007). In other words, when we say that students have power in SWH classrooms, this does not exclude or diminish the power of their teachers; our theoretical framework does not assume a fixed quantity of power in any given social space.

In SWH classrooms, while it is recognized that teachers do have an ultimate responsibility and power over their classrooms, students are also empowered. Students engage in power both in terms of authority, as they negotiate what activities should be explored in class and the methods by which they will be explored, and in terms of ability. Students generate knowledge through their investigations, share this knowledge with their peers and their teacher, and work to evaluate both the knowledge they generate and the knowledge generated by others. As a part of this process, they engage in spontaneous scientific talk, which has been found to be rare in most science learning environments (Lemke, 1990; Moje et al., 2001). The generation of knowledge through argumentative reasoning based on public debates and critiques of claims and evidence is an important way in which students can express power in the SWH classroom. In this way, science knowledge becomes understood as something that is negotiated rather than something that is immutable; a truism that carries into an accurate understanding of real-world science and the associated practices of science.

Students' access to power is deeply tied to their access to agency. Agency as discussed here refers to projected agency; the ability of a person to internally look forward toward new paths and directions (Emirbayer & Mische, 1998). In terms of the classroom, agency can be seen as the internal processes of students as they relate to driving the flow of instruction

(Reeve & Tseng, 2011). In a traditional classroom, students have minimal agency (Bandura, 2006) as most choices, such as what to study and in what ways topics will be explored, are made for students by teachers. Low-agency classrooms of this type correlate negatively with academic achievement (Koenigs, Fiedler, & Decharms, 1977; Reeve, Deci, & Ryan, 2004). Additionally, without internal access to agency, students are unable to create meaningful outward expressions of power.

Access to power and agency are particularly important issues when we consider the success of historically underserved student populations, which have been seen to experience particularly strong positive effects under the SWH approach in the context of the large-scale randomized control trial (Laugerman, 2013). Many of the difficulties faced by nonmainstream students are centered in language. The language of science is often seen by these students as exclusive and exclusionary (Goodman et al., 2011; Hodson, 1999; Rossato, 2007). Science is seen as something that belongs to the mainstream, not to these students' communities (Diaz-Rico & Weed, 2002; Duran, 1998; Hildebrand, 2001; Tobin & McRobbie, 1996). These issues related to culture and science have been identified as significant demotivating factors in a wide variety of subgroups in American culture (Lee, 1997; Lee & Fradd, 1996; Rakow & Bermudez, 1993; Rosenthal, 1993).

One of the reason mainstream students tend to be more successful in science may be that the language practices they use as home discourse already have much in common with those language practices used in schools. As seen in research on cross-cultural literacy, middle-class White children come to school already possessing many of the skills needed to do well in school (Gee, 1990). The home language practices of middle-class White people has been shown to involve more of the elements found in scientific argumentation than the home discourse of many other cultural groups. From an early age children from this group are asked open-ended questions by their parents; parents provide reasoning for why young children may or may not do certain things, and children are both expected to provide reasoning for their actions and are asked to provide reasoning for why they may think certain ways and hold certain opinions (Choi, Nisbett, & Smith, 1997; Gee, 1990; Peng & Nisbett, 1999). These behaviors are not culturally universal. In many cultures, children are expected to learn social norms through observation rather than explicit instruction; children are not asked open-ended questions, are told what to do through direct statements rather than being reasoned with, and are less likely to be engaged in guided or directed Aristotelian-style dialog with their parents (Neuman, 1996). These differences do not indicate that parents from these cultural groups are uninvolved with or uninvested in their children. These cultural groups have different and valid ways of interacting with their children. Various cultural groups within the United States interact with their children differently and utilize different forms of literacy, but these differences when studied by ethnographers do not indicate deficit (Delpit & Dowdy, 2002; Heath, 1983; Purcell-Gates, 2007; Smith & Dixon, 1995).

If power and agency are connected to language, and the SWH approach improves students' access to the discipline-specific language of science, this may help to explain the extent to which students from underserved demographic groups experience success with the SWH.

Linguistic Markers of Access and Power

If we recognize that SWH students have access to agency and power, the question we must ask is through what avenues does this access arise? Our hypothesis is that the language practices utilized by SWH teachers and students as they engage in negotiation provide avenues for agency and power, thus allowing students to develop as stakeholders. Characterizing talk in SWH classrooms will help us to understand these avenues, and thereby

develop our understanding of negotiation, most particularly that aspect of negotiation that hinges on stakeholder participation. Talk and language are nonneutral; they always convey messages beyond those contained in their vocabulary (Fiske, 1994). Ways of talking include tone, tempo, conventions for dialog exchange, nonverbal signaling, and many other markers (Gee, 1988).

Many of these nongrammatical features of language serve to encode power. Ways of talking such as tone, tempo, and vocabulary choices indicate both how a speaker chooses to express their own power and their perception of the relative power of their listeners; the use of formal versus informal speech is a way in which individuals can express power. As we examine the differences between SWH and control classrooms, we have begun to consider that linguistic formality may underlie many of the differences we see (Choi et al., 2010). As one's perception of oneself as a stakeholder is directly tied to the degree to which one perceives oneself to have power, we anticipate that speech characteristics related to formality will change as negotiation becomes an increasingly predominate paradigm within a classroom. Accordingly, the use of formal and informal speech may be different between SWH and traditional classrooms, which are often deficient in dialog and negotiation.

Many of the ways of talking Gee describes follow similar formality patterns across languages and cultures. Speech that is low in tone and slow in tempo, for example, is a consistent marker of linguistic formality, whereas certain types of nonverbal signaling, such as laughter, are cross-cultural markers of linguistic informality (Gorham, 1988; Irvine, 1985).

The presence of conventional turn-taking as opposed to fluid conversation has also been found to be consistently tied to linguistic formality (Irvine, 1988). If the presence of dialog is related to the degree of formality present in spoken language, and scientific argumentation can also be meaningfully framed as dialog (Duschl, Schweingruber, & Shouse, 2007), we can understand many aspects of scientific argumentation in terms of linguistic formality. This allows us to look at argumentation with a lens of access and power that allows complex connections to the larger concept of negotiation. All four aspects of negotiation (defining problems, finding solutions, encouraging participation, and reaching consensus) require dialog. Dialog is not simply the presence of two or more voices in a discussion, but includes complex activities such as reaching consensus, which requires many conversational turns and active engagement in sophisticated linguistic forms such as construction and critique (Ford & Forman, 2006). Accordingly, dialog can be thought of as an occasion where these voices flow through one another, developing, turning, and reflecting upon ideas (Isaacs, 1993). Dialog is a form of deeply engaging with the other, allowing for exploration of and complexity in ideas through participation and interrelationship (Schein, 1993). For dialog to occur, all individuals must have equitable access and power in the classroom, where they feel an ability to express their ideas, and have reasonable expectations that their ideas will be considered and respected.

Accordingly, as we seek further language characteristics that may signal the presence of negotiation within a classroom, there is a need to look for signs of dialog. As the presence of dialog markers increases, language formality decreases. Markers of dialog of possible interest for study include the frequency of dialog interchange between students and teachers and among students, the space permitted for student–student talk, and the presence of speech summarization.

The frequency of dialog interchange, or how often speakers change in the classroom, is a logical indicator of quality dialog when we define dialog as involving flow (as above in Isaacs). Building upon this idea, examining the frequency of dialog interchange both between students and teachers and among the student population may be a fruitful way of analyzing whether negotiation in particular classrooms exists purely between students and teachers or if it disseminates into students' peer interactions.

An environment ripe for dialog is somewhat unpredictable; it is negotiated as both students and teachers utilize and develop the statements of students (Boyd and Rubin, 2006). An important indicator of classroom dialog is that, while the teacher's voice remains significant, it becomes only one of many voices (Nystrand, Wu, Zeiser, & Long, 2003). As teacher voice contributes less to the classroom, more conversational turns and thus more meaningful dialog can occur (Boyd and Rubin, 2006). When teachers utilize the SWH approach, students engage in more talk (Martin, 2009). These studies all indicate that student–student talk is a meaningful component of dialog.

Speech summarization also indicates the presence of dialog, as in dialog it is necessary that listeners conceptualize the spoken thoughts of others so that their own thoughts can be developed within a culturally appropriate context (Vygotsky, 1987). Though Vygotsky would argue that this conceptualization takes place internally, instances of observed speech summarization can provide evidence that these internal processes are occurring in both students and teachers.

Thus, in seeking to examine language's relation to power and agency within an immersive approach to inquiry such as the SWH approach, this study was guided by the following questions:

1. How do language markers related to power and agency, including both nongrammatical factors such as tone and tempo of speech as well as the characteristics and qualities of that speech's dialog, change as the SWH approach is implemented in the science classroom?
2. Do differences in spoken language between SWH and traditional classrooms allow us to understand differences in student success in terms of access and power?
3. Can these differences help us to clarify the concept of negotiation as it relates to science education?

As we consider these questions, it should be noted that the SWH is utilized in this study as a specific instance of an immersive approach. While the conclusions we draw from this study will be generated in the context of the SWH, it would be reasonable to anticipate that they may also give insights into how the speaking space within elementary science classrooms shifts as teachers begin to implement other immersive approaches in their classrooms. As the NGSS call for a nationwide shift to immersive approaches in science education, work to describe and characterize the process of broad curriculum change will be valuable for both general understanding and improving professional development.

METHODS

Design

This study was conducted within the context of a random control trial (RCT) of the SWH approach. In an RTC, subjects are randomly assigned to treatment or control groups. In this case, this meant that schools were randomly assigned to the control group, which would continue traditional science instruction, or the treatment group, which received professional development to allow teachers to implement the SWH approach. This particular implementation was done on a large scale. Forty-eight schools were involved across a large Midwestern state, though not all of the schools were included in this study.

During the RCT, staff from the SWH project visited treatment and control schools throughout the course of the study, both for the purpose of data collection and to address participants' questions or concerns as they arose. In two of the project's regional clusters, research team members were available for regular observational studies. These team

members visited treatment and control schools within their cluster to collect quantitative data related to the use of spoken language by students and teachers in the science classroom. The purpose of these observations was to better understand any differences in language use between treatment and control classrooms, as well as to explore how these potential differences might arise, so as to better understand how the discourse requirements of the SWH approach inform its impact on students.

Context

The SWH approach is an immersive approach to argument-based inquiry, which has numerous discourse requirements. To implement the SWH approach, teachers cannot simply reproduce activities learned in professional development. The approach is student centered and student driven. In the SWH classrooms, students generate questions related to "big ideas" about science topics. The students design investigations to gather data and generate evidence that will allow them to support claims related to their questions (Norton-Meier et al., 2008). Accordingly, the SWH classroom is dynamic. While the same "big ideas" may be addressed within a grade level every year, it must be expected that the questions students ask and the experiments they design to investigate these questions will be different. This means that teachers need to develop a different type of skillset than they may have traditionally utilized when teaching a SWH classroom. Rather than mastering a fixed set of curricular activities, SWH teachers must cultivate a strong ability to communicate with and foster communication among their students. For a student-driven and student-centered classroom to succeed, it must be rich in dialogic discourse. Both teacher and, crucially, student voices must be present and expressive.

Participants

For this study, the science lessons of classrooms in Grades 3–5 were observed. Observed schools had demographically similar student bodies, as presented in Table 1. Student populations were more than 90% White. Virtually all students spoke English with a native degree of fluency. Compared to national averages, most schools had relatively few students receiving free or reduced lunch, a common indicator of poverty in the United States, with percentages of students receiving assistance ranging from 10 to 43.

All of the schools observed were located in rural to suburban areas within one Midwestern state. Sites were geographically distant from each other, occupying regions at both the western and eastern edges of the state. While populations at the eastern and western edges of the state are ethnically, linguistically, and socioeconomically similar, they have significant political and religious differences. One side of the state leans politically liberal while the other leans conservative. While both populations are predominantly Christian, one side of the state is largely associated with mainstream Protestant and Evangelical churches, whereas the other region harbors numerous smaller, culturally unique religious groups. Many of these communities are bilingual, with languages such as German, Dutch, or Russian commonly spoken alongside English.

TABLE 1
Pooled Demographics of Treatment Groups

Treatment	White	English Learner	Free/Reduced Lunch
SWH	96	1.7	33
Traditional	98	1.3	36

Most observed teachers were women. Of the 76 classrooms observed, four were led by men. All teachers were White and had native fluency in English. Their levels of teaching experience varied greatly. Our research population included new teachers, teachers approaching retirement, and individuals at all stages of professional growth in between. All treatment teachers observed were exposed to the same amount of professional development related to the SWH approach.

Instrument

High scores on honorifics, vocabulary, slow tempo, and low tone were assumed to characterize formal speech, whereas high scores on slang, relaxation, speech summarization, frequent dialog interchange, and free speech were assumed to characterize informal speech. For further clarification, see Table 2. These assumptions are supported by Irvine's work in linguistics on honorifics, status, and style in language (1988, 1985), as well as Gee's work on discourses (1988). Discipline-specific vocabulary has been identified as a variable particularly relevant to science education (Richter, 2011; Schoerning, 2014). These studies all support the validity of the instrument. Face validity was further established through a workshop session with an external expert on sociocultural and language interaction. Further explanation of scoring for these factors can be seen in Table 2.

All classrooms were assessed via the Spoken Language Formality Characterization Tool (SLFCT), an instrument developed for this study that can be used to quantify the above factors. The instrument, reproduced below, consists of 18 Likert scale measures assessing elements of student and teacher language.

Teacher Speech and Listening 1. Never 2. Infrequently 3. Sometimes 4. Frequently 5. Always					
1. Uses slang and popular expressions.	1	2	3	4	5
2. Uses honorifics when referring to self or others.	1	2	3	4	5
3. Engages in fluid dialog, without formal request to speak.	1	2	3	4	5
4. Exhibits nonverbal relaxation markers.	1	2	3	4	5
5. Favors the use of formal/technical vocabulary.	1	2	3	4	5
6. Speaks in a slow tempo.	1	2	3	4	5
7. Speaks with a low tone of voice.	1	2	3	4	5
8. Teacher summarizes student talk before making further comment.	1	2	3	4	5
9. Extended sequences of student–student talk occur.	1	2	3	4	5
10. Engages in frequent dialog interchange; absence of lecturing.	1	2	3	4	5
Student Speech and Listening **1. Never 2. Infrequently 3. Sometimes 4. Frequently 5. Always**					
1. Uses slang and popular expressions.	1	2	3	4	5
2. Uses honorifics when referring to self or others.	1	2	3	4	5
3. Engages in fluid dialog, without formal request to speak.	1	2	3	4	5
4. Exhibits nonverbal relaxation markers.	1	2	3	4	5
5. Favors the use of formal/technical vocabulary.	1	2	3	4	5
6. Speaks in a slow tempo.	1	2	3	4	5
7. Speaks with a low tone of voice.	1	2	3	4	5
7. Students summarize peer talk before making further comments.	1	2	3	4	5
8. Engages in frequent dialog interchange; absence of lecturing.	1	2	3	4	5

TABLE 2
Scoring of Formality Characteristics

Formality Characteristic	A Score of 1 (never)	A Score of 5 (always)	Which is Formal?
Use of slang/popular expressions	No use of slang or popular expressions in the classroom.	Nearly all speech utterances use slang or popular expressions.	Absence of slang (1)
Use of honorifics	No use of honorifics, such as Mrs., Dr., teacher, principal, or first name/surname pairings.	Nearly all personal referents use honorifics such as Mrs., Dr., teacher, principal, or first name/surname pairings.	Presence of honorifics (5)
Fluid dialog: no formal requests to speak	All student speech is preceded by formal request, such as hand-raising or being called upon.	All members of the classroom speak freely via natural conversational turns, interjection, or interruption.	Absence of fluid dialog (1)
Nonverbal relaxation markers	Body language includes stiff posture and little movement. Absence of laughter or pronounced facial expressions.	Body language includes fluid posture and frequent movement. May laugh other emotive sounds. Facial expressions tend to be pronounced.	Absence of nonverbal relaxation markers (1)
Use of formal/technical vocabulary	No use of discipline-specific vocabulary words in the science classroom, such as igneous, solute, etc.	Nearly all speech utterances use discipline-specific vocabulary words in the science classroom.	Presence of formal/technical vocabulary (5)
Slow speech tempo	Speech maintains normal to quick conversational tempo for each individual during science, relative to outside interactions.	Individuals speak artificially slowly during science, relative to outside interactions.	Presence of slow speech (5)
Low vocal tone	Tone of individuals' voices remains normal to artificially high during science, relative to outside interactions.	Tone of individual's voices becomes artificially low during science, relative to outside interactions.	Presence of low vocal tone (5)
Speech summarization	Individuals do not summarize each other's speech before adding their own input to the dialog.	Individuals nearly always summarize each other's conversational contributions before adding their own input to the dialog.	Absence of speech summarization (1)
Frequent dialog interchange	Conversational turns in the classroom are rare. Most speech consists of teacher lecturing.	Conversational turns in the classroom are very common. Neither teacher nor students lecture. Most speech is dialogical.	Absence of frequent dialog interchange (1)

Researchers observed a full science lesson before filling out this instrument. Teacher behavior was scored by observing the primary classroom teacher. The language behaviors of paraprofessionals were not included in this study. The behavior of the students as a class was scored for the student portion of the questionnaire, rather than relying on observation of any one particular student.

Data Collection

Quantitative assessment of language formality was done at 11 schools, five of which used traditional practices and six SWH. Thirty-one SWH and forty-five traditional classrooms were visited across these schools. The discrepancy in the classroom-level sample size is largely due to the fact that one of the traditional schools was very large.

Schools were visited by four field researchers over a 2-year period. Each individual classroom was visited every 4–6 weeks. Field researchers observed science lessons for Grades 3–5 and scored language formality using the SLFCT as described above. To ensure inter-rater reliability, the field researchers met twice a year to train with the scoring instrument. The first meeting took place before the beginning of school year one, and the second meeting during the winter break. This schedule was repeated in the second year of the study.

During these meetings, the field researchers practiced scoring classroom videos using the instrument and discussed any discrepancies between the scores they assigned until all members of the group were in agreement. Each meeting lasted approximately 4 hours and involved discussion of how and why different Likert scores were assigned to different language behaviors in various videos. In this way, field researchers were able to reduce the subjectivity of Likert scoring by reaching consensus among themselves regarding what subtle yet objective qualities should result in various numerical scores. Owing to the involvement of the field researchers in the larger SWH research project and the school districts in which they worked, field researchers were aware of the treatment or control statuses of the classrooms they visited. As this introduced concerns related to observer bias, it was judged particularly important to develop standards that were as objective as possible with regard to numerical scoring of language-related behaviors. Field researchers frequently communicated by phone and e-mail between meetings so as to maintain consensus, and data were entered into a general database at monthly intervals, allowing for rapid detection of any potential inter-rater reliability problems. When the scores were analyzed reliability was high, with Cronbach's alpha = .91.

Data Analysis

Analysis of SLFCT data was performed in PASW18. Data were structured longitudinally at 6-week intervals, resulting in 13 timeblocks. For each timeblock, the language characteristics of traditional and SWH classrooms were compared via analysis of variance. Significant differences in language style between SWH and traditional classrooms were revealed. Differences that proved significant across timeblocks were selected for further graphical analysis. Globally significant traits were analyzed by plotting mean values for all timeblocks.

RESULTS

Findings

This study examined the language use of students and teachers in SWH and traditional classrooms over a 2-year period. Data analysis indicated that significant differences in

TABLE 3
Year 1 Results

Language Characteristic		*df*	η	*F*	*p*
Thonorif	Between groups	1	10.107	10.407	.001
	Within groups	186	0.971		
	Total	187			
Tvocab	Between groups	1	6.916	7.412	.007
	Within groups	186	0.933		
	Total	187			
Tslow	Between groups	1	11.802	11.484	.001
	Within groups	186	1.028		
	Total	187			
Tlow	Between groups	1	6.570	5.210	.024
	Within groups	186	1.261		
	Total	187			
Sslang	Between groups	1	10.712	14.931	.000
	Within groups	185	0.717		
	Total	186			
Srelax	Between groups	1	20.077	21.692	.000
	Within groups	186	0.926		
	Total	187			
Svocab	Between groups	1	15.040	16.382	.000
	Within groups	186	0.918		
	Total	187			
Sslow	Between groups	1	3.538	3.016	.044
	Within groups	186	1.173		
	Total	187			

Significance: $p < .05$.

language style emerged between SWH and traditional classrooms over the study period. These differences developed over time, with more significant differences seen in year 2 than year 1. See Tables 3 and 4. When significant linguistic factors are examined, two patterns of change can be found. Language behaviors that change in year 1 can be broadly grouped into the category of power-related conventions. Language behaviors that change in year 2 can be broadly grouped into the category of argumentation conventions. From these results, we infer that power conventions in a classroom change before meaningful changes in argumentation conventions occur. This relationship implies that students must gain access and power before they are able to engage in and produce dialogical discourse.

Significant Differences Emerge Mechanistically Over Time

When data are analyzed by year, it can be seen that numerous significant differences emerge over time. Analysis of year 1 data reveals significant differences in eight of the 19 language behaviors studied (see Table 3). For teachers, significant factors at year 1 included the use of honorifics, discipline-specific vocabulary, and artificially low and slow speech. These factors were all more commonly found in the speech of teachers of traditional classrooms. For students, significant factors at year 1 included the use of slang, relaxed body language, discipline specific vocabulary, and artificially slow speech. While the use

TABLE 4
Year 2 Results

Language Characteristic		*df*	η	*F*	*p*
Tfluid	Between groups	1	12.618	9.051	.003
	Within groups	116	1.394		
	Total	117			
Trelax	Between groups	1	57.141	26.319	.000
	Within groups	116	2.171		
	Total	117			
Tvocab	Between groups	1	11.802	9.440	.003
	Within groups	116	1.250		
	Total	117			
Tslow	Between groups	1	6.985	5.815	.017
	Within groups	116	1.201		
	Total	117			
Tlow	Between groups	1	11.160	10.683	.001
	Within groups	116	1.045		
	Total	117			
Tsumm	Between groups	1	49.004	45.847	.000
	Within groups	116	1.069		
	Total	117			
Tss	Between groups	1	27.374	14.375	.000
	Within groups	116	1.904		
	Total	117			
Tfrequchg	Between groups	1	53.017	34.212	.000
	Within groups	116	1.550		
	Total	117			
Sfluid	Between groups	1	19.906	20.519	.000
	Within groups	116	0.970		
	Total	117			
Srelax	Between groups	1	43.592	16.144	.000
	Within groups	116	2.700		
	Total	117			
Svocab	Between groups	1	3.895	3.376	.049
	Within groups	116	1.154		
	Total	117			
Sslow	Between groups	1	5.241	7.682	.006
	Within groups	116	0.682		
	Total	117			
Slow	Between groups	1	3.093	4.364	.039
	Within groups	116	0.709		
	Total	117			
Ssumm	Between groups	1	13.323	20.640	.000
	Within groups	116	0.646		
	Total	117			
Sfreqchang	Between groups	1	68.334	52.006	.000
	Within groups	116	1.314		
	Total	117			

Significance: $p < .05$.

of slang was more prevalent among students of traditional classrooms, the presence of the other three significant factors was more commonly seen in SWH students.

In year 2, the eight factors that emerged as significant in the first year of the study largely remain significant, with the exceptions of slang and honorific use (see Table 4). More significant language behaviors also emerge, with 15 of the 19 factors having p values of less than .05. These newly significant language behaviors include, among both teachers and students, fluidity of speech, the presence of speech summarization, speech between student speakers while the teacher is talking, and frequent changing of speakers. All of these language behaviors were seen to be much more common in SWH than traditional classrooms.

Analysis of the data by year allows us to see that linguistic changes may occur in a stepwise fashion. The first group of language behaviors to change mainly involves speech conventions related to power expression (Irvine, 1988). The second group of language behaviors to change relate primarily to the presence or absence of dialog (Schoerning & Hand, 2013).

There are Two Distinct Patterns of Change: Power and Argumentation

In Figures 1 and 2, two examples from the first group of significant differences are graphed by time point, showing mean scores over the 2-year period of the study. Analysis has shown that SWH students are more likely to utilize this first group of power-related language behaviors than their traditional counterparts, whereas SWH teachers are less likely to use these language behaviors than traditional teachers. Here, we visualize how two of these language behaviors change over time in an SWH classroom. The increase in students' use of formal speech conventions, such as using artificially slow speech or discipline-specific vocabulary, is correlated to their teacher's decreased utilization of those

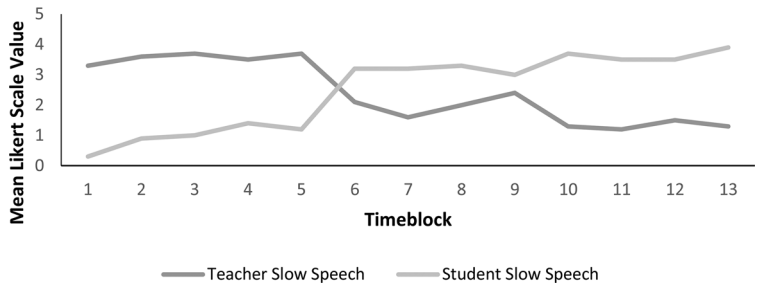

Figure 1. Slow speech in SWH classrooms.

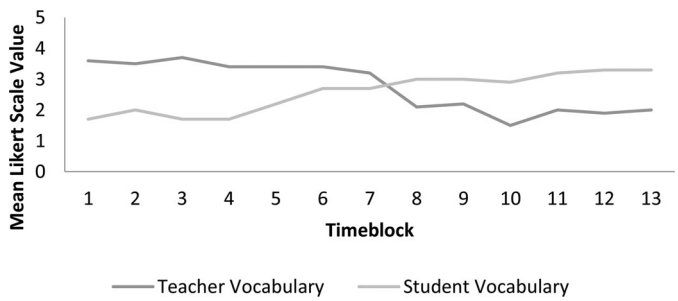

Figure 2. Vocabulary in SWH classrooms.

language behaviors. While not shown, this pattern was true of all significant linguistic factors related to power in speech conventions, including vocabulary use, artificially low or slow speech, relaxed body language, and fluidity of speech.

In Figure 1, we see how the use of artificially slow speech changes over time in SWH classrooms as teachers learn to implement the SWH approach. Teachers' use of this behavior decreases over time, whereas students' use of the behavior increases. As seen in Irvine's work on formality and language, this indicates that students' expressions of access and power increase over time.

The same pattern is shown in Figure 2, which shows how the origin of science vocabulary and the population who use it changes over time in the SWH science classroom. As teachers learn to implement the SWH approach, their use of discipline-specific vocabulary decreases, whereas student use and production of discipline-specific vocabulary increases. Student use of science vocabulary is a known power issue, as explored by Lee, Rakow, and the author. This result is useful not only in terms of indicating student power, which is understood as increasing in tandem with increased vocabulary production, but of the direction of learning in the SWH classroom. In the SWH classroom, learning appears to increasingly originate with students.

The patterns shown in Figures 1 and 2 are further clarified below, where excerpts of classroom dialog from timeblocks 1 and 12 are reviewed.

Early Dialog

T: (slowly) So what rocks would we find maybe in places with water, like under a river?
S: The kind of rocks—the rocks that are squished together.
T: Trevor, we have to use the right words. What's the right word for that?
S: (no response)
T: Sedimentary. We call those sedimentary rocks.

Late Dialog

S1: Look here—(slowly) look on this part here.
S2: The rocks come from volcanoes.
S1: From the heat!
S3: (slowly) write those words down. (to teacher) How do you say this word? Igneous?

As can be seen in these dialog excerpts, substantial changes take place between SWH classrooms early in the study, where fairly traditional instructional patterns can be seen, and SWH classrooms run by teachers that are more experienced with the approach. These changes reflect changes in students' access and power in the elementary science classroom. Vocabulary words begin to originate with students, and students use various markers of power in their speech, such as artificially slow tempos.

In Figure 3, we visualize how the second group of significant factors changes over time. These factors, which can be broadly related to the presence of dialog, include the frequency with which speakers change in the classroom, the presence of student–student speech while a teacher is also talking, and the presence of speech summarization. These language behaviors, when visualized within the SWH classroom over the 2-year period of the study, can be seen to change in a different way than power-related speech conventions. While we can see a pattern of formality inversion in the first group, student and teacher language behaviors related to dialog appear to change together. Again, while not shown, this pattern was true for all significant language behaviors in this second group. Analysis shows that as SWH teacher utilization of these behaviors increases, student behavior also

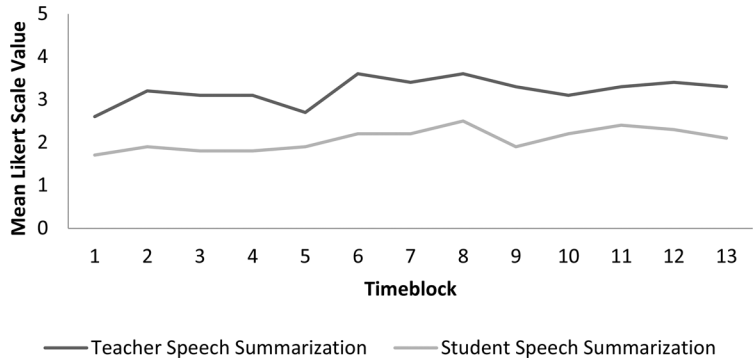

Figure 3. Speech summarization in SWH classrooms.

increases. The presence of these dialog-related language behaviors is markedly higher in SWH students' and teachers' speech than in that of their counterparts in traditional settings.

This pattern of related change is clarified in the classroom dialog excerpts seen below, which are also taken from timeblocks 1 and 12:

Early Dialog

S1: It took four big washers to make the car go to the edge of the table.
S1, S2, S3: write. S1 consults notebook.
S1: Then it took eight little washers and one big washer to make the car go to the edge of the table when we used both washers.
S4: Where are we?
S1: How many big and little washers.

Late Dialog

S1: It took three big washers to make the car go to the edge of the table.
S2: Three big washers?
S3: It took their group four big washers.
S1: But their car is different.
S2: Their car is different, it has the little wheels on it.

In these excerpts, several statistically significant behaviors related to dialog can be seen. While students from the later timeblock do engage in more speech summarization, they also engage in more frequent dialog interchange and more meaningful student–student speech. While Student 1 in the early student group is speaking to the other students, this students' speech appears to mirror the behavior of a traditional teacher. This student does not engage in dialog with the other members of his or her group. The late group's Student 1 did assume a leadership role, but like a more experienced SWH teacher Student 1 allows room for others to speak. Importantly, the other students engaged in the second dialog excerpt appeared to come to the group discussion with the assumption that they should speak, where this did not seem to be the case for the other students in the first group.

DISCUSSION

While this study has some limitations related to the fairly narrow demographics of the research population, significant results were found. In previous studies, we have proposed that the SWH approach and negotiation are deeply intertwined (Hand et al., 2009). Now we

see that as teachers move toward successful implementation of the SWH approach, talk in their classrooms changes in many ways. Both students' and teachers' use of formal aspects of language change over time, with two distinct types of changes occurring as teachers' experience with the approach increases. First, behaviors related to the power conventions of language change. Then, dialogic behaviors emerge. This gives us two questions to address. What do these changes mean for students in gaining access and power in the science classroom? How does this relate to the concept of negotiation as pertaining to science education?

Power Conventions of Language

A goal of science instruction is to give students the tools to engage in science as science is practiced, which includes developing the linguistic skills necessary to participate in the scientifically literate community. Some of these linguistic skills involve aspects related to power, such as the mastery of discipline-specific vocabulary.

One might anticipate that teachers in traditional classrooms would utilize more language characteristics related to power conventions, such as the use of discipline-specific vocabulary, honorifics, and speech with artificially low tones and slow tempos. The banking theory of education would lead one to think that if a teacher frequently utilized discipline-specific vocabulary, this vocabulary would be retained and utilized by his or her students (Rossato, 2007). Similarly, one might think that students might mirror other power-related conventions of scientific language after observing them in their teachers. Finding that teachers who utilize fewer power-related linguistic practices produce students who engage in more of these desired, empowered language behaviors should lead us to question why and how language is shaping the environments of these types of classrooms.

When the teacher no longer extensively utilizes power-related language behaviors in the classroom, the degree to which the teacher is the most important person in that classroom is diminished. An environment in which students can develop a sense of power and agency opens up space which was once fully occupied by the instructor. The space is defined by the language behaviors of SWH teachers, which include the absence of traditionally authoritarian vocalization and body language, the ability to speak freely, and the recognition of the content of speech regardless of its vocabulary. These teacher language behaviors create pathways by which students can gain entry to the classroom dialog.

Students are able to utilize these linguistic pathways as avenues for agency and power. In the absence of teacher speech bearing authority markers such as low tone and slow tempo, or in the presence of relaxed, nonauthoritarian body language, students may feel less concerned about being punished or corrected by authority figures. This gives them greater opportunity for agency; they may feel they have more freedom to participate in class or think divergently. Similarly, a teacher who values the content of student speech above the vocabulary used in student speech, or a teacher who allows students to speak without formal permission, creates a similar avenue for agency.

These language changes seem to be persistent and self-enforcing. Although SWH teachers are instrumental in creating the environment of an SWH classroom, student speech and teacher speech do not have a strictly dichotomous power relationship. Once a SWH style classroom environment is established, student speech also influences teacher speech. If students begin to access the opportunity provided through a teacher's language behavior by, for example, engaging in on-topic dialog with each other and their teacher during science class, the teacher's language behaviors will be reinforced. The teacher will be more likely to speak freely and informally during class if this behavior results in productive, engaged students. This opens further avenues for student agency and power, allowing students to

become increasingly involved in and engaged with the conversations that take place in the science classroom, which further enforces a reduced use of power conventions in teacher speech, and so on. Similar cycles of positive reinforcing behaviors have been noted in classrooms in regard to students' engagement and teachers' instructional behaviors (Pelletier, Seguin-Levesque, & Legault, 2002; Skinner & Belmont, 1993).

The styles of teacher speech that characterize SWH classrooms create an environment that allows the distinct student speech of SWH classrooms to develop and thrive. When we consider this in the context of negotiation theory, this is a clear example of how the language behaviors of science teachers can encourage one of the key aspects of negotiation: fostering the participation of stakeholders.

Power Leads to Dialog

This study has shown that language behaviors related to the presence of dialog do not change until after significant changes occur in the frequency of power-related language behaviors. This may indicate that in order for the argumentative aspects of negotiation to occur, including defining problems, finding solutions, and reaching consensus, it is first necessary to establish the participation of stakeholders by inverting the use of power conventions in the classroom. In order for students to productively and confidently participate in dialogic conversations, they must have opportunities for both access and power.

The SWH approach is an approach to argument-based inquiry. Accordingly, for teachers to successfully implement the SWH approach they must utilize argumentative negotiation in their classrooms, which requires changing student behavior. In a traditional classroom, student voice has a limited role. Students are generally expected to remain quiet unless they are called on by their teachers. When called on, their speech role is generally limited to giving "right answers" or asking "good questions," while other student speech is often seen as disruptive. Teachers may interpret student–student dialog in the context of teacher-led discussion as interruption, even if the students are engaged in discussing a relevant topic. Except in expressly permitted contexts, student–student dialog outside of a teacher-led discussion is often also seen as inappropriate regardless of the dialog's content. Dialog interchange in traditional classrooms tends to be infrequent and purely teacher-directed.

Successful SWH teachers cannot engage in argumentation by themselves, it is necessary that their students participate in argumentation with them. When student speech is an essential part of the classroom, the traditional teaching behaviors described above quickly prove counterproductive. To encourage student speech, teachers summarize student speech, thus demonstrating both to the speaker and their peers that students' speech contributions are important. Teachers engage in more frequent and more fluid dialog interchange, give students more opportunities to speak, and direct students to speak with each other even in teacher-led contexts. Students absorb these lessons and implement these behaviors in discussions with their peers, where significant increases are seen in the frequency of the same linguistic moves used by their teachers.

The direction of these changes is significant. While those behaviors related to power conventions, which change first in the SWH classroom, occur inversely in students and teachers, with the frequency of student behavior increasing as teacher behavior decreases, the pattern of change related to dialogic language behaviors is different. When we consider dialog-related language behaviors, we find that students are learning from teachers as models. Student behavior frequency only increases after teacher behavior frequency increases. Students do not appear to need to be explicitly taught how to engage in expressions of agency and power; these are skills they presumably bring to the classroom from the

linguistic toolsets of their larger lives. However, students do seem to need to be explicitly taught how to engage in dialogic forms of negotiation.

Though the population utilized in this study was predominantly White, students from a variety of linguistic, ethnic, and cultural backgrounds were included. Thus, it is reasonable to think that the student–teacher language relationships explored in this study should prove relevant to why the SWH and other forms of ABI are beneficial to so many types of students that traditionally struggle to perform in science class (Hand et al., 2009). While it has been previously supposed that language informality gives traditionally disadvantaged students both the comfort and the confidence that allows them to meaningfully engage in science education (Duran, 1998; Rakow & Bermudez, 1993), this study allows us to see some pathways by which the effect may be occurring. Students are able to gain access and power in the classroom setting through the use of power-related language behaviors that apply to their everyday lives. This may serve to reduce their perceptions of science as an exclusive field, thus increasing participation by increasing student access to agency. Then, through explicitly teaching the language skills involved in building and defending formal arguments as their implementation of the approach improves, SWH teachers give their students the skills needed to engage in dialogic negotiation.

CONCLUSIONS

While further research is needed to better understand whether and how language behaviors affect science achievement in diverse populations, this study demonstrates that there are major changes in the way students and teachers talk in inquiry-based and traditional elementary science classrooms, that these changes are emergent, and that there are patterns by which these changes occur. By actively inverting some of the conventions of formal language within their first year of practice, SWH teachers create avenues for access and power for their students, engaging them as stakeholders in the science classroom. This appears to increase the abilities of students to engage in argumentative aspects of negotiation, as seen in the second year of the study.

While this study has demonstrated that the language of environments of inquiry-based science classrooms and traditional science classrooms differ, and identified some of the specific ways in which these language environments change, further research is necessary to identify if and how changes in these particular factors, such as vocabulary use and speech summarization, are involved in this change. Currently, it is unclear whether these relationships are correlational or causal with changes in the classroom environment. The descriptive work done in this study does not allow us to fully understand how or why classroom language environments change, but it does help characterize these changes. Further research on this topic, involving deeper exploration of various significant variables, will be necessary to develop a fuller understanding of the relationships between these language behaviors, access, and power.

The applicability of these patterns to affect teacher change through professional development should be further explored. If teachers can be made more aware of how their use of language affects students, it is possible they will be able to shift their classrooms more efficiently toward immersive, student-centered approaches to science education. The classroom talk in which students and teachers engage is rich in clues regarding how and why approaches to science teaching and learning can foster or discourage student success. By examining language as a defining aspect of the classroom environment, we will be better able to understand how to successfully implement the NGSS in the science classroom.

The research reported here was supported by the Institute of Education Sciences, U.S. Department of Education, through Grants R305A090094 and R305B10005 to the University of Iowa. The opinions expressed are those of the authors and do not represent views of the Institute or the U.S. Department of Education.

REFERENCES

Abi-El-Mona, I., & Abd-El-Khalick, F. (2006). Argumentative discourse in a chemistry high school classroom: An exploratory study. School Science and Mathematics, 106(8), 349–361.

Akkus, R., Gunel, M., & Hand, B. (2007). Comparing an inquiry-based approach known as the Science Writing Heuristic to traditional science teaching practices: Are there differences? International Journal of Science Education, 29(14), 1745–1765.

Bandura, A. (2006). Toward a psychology of human agency. Perspectives on Psychological Science, 7(2), 164–180.

Boyd, M., & Rubin, D. (2006). How contingent questioning promotes extended student talk: A function of display questions. Journal of Literacy Research, 38(2), 141–159.

Cavagnetto, A. R. (2010). Argument to foster scientific literacy: A review of argument interventions in K–12 science contexts. Review of Educational Research, 80(3), 336–371.

Chen, Y.-C., Hand, B., & McDowell, L. (2013). The effects of writing-to-learn activities on elementary students' conceptual understanding: Learning about force and motion through writing to older peers. Science Education, 97(5), 745–771.

Choi, I., Nisbett, R. E., & Smith, E. E. (1997). Culture, category salience, and inductive reasoning. Cognition, 65(1), 15–32.

Choi, A., Notebaert, A., Diaz, J., & Hand, B. (2010). Examining arguments generated by year 5, 7, and 10 students in science classrooms. Research in Science Education, 40(2), 149–169.

Cobb, S. (2000). Negotiation pedagogy: Learning to learn. Negotiation Journal, 16(4), 315–319.

Crawford, B. A., Zembal-Saul, C., Munford, D., & Friedrichsen, P. (2005). Confronting prospective teachers' ideas of evolution and scientific inquiry using technology and inquiry-based tasks. Journal of Research in Science Teaching, 42(6), 613–637.

Creedy, D., & Hand, B. (1994). The implementation of problem-based learning: Changing pedagogy in nurse education. Journal of Advanced Nursing, 20(4), 696–702.

Delpit, L., & Dowdy, J. K. (2002). The skin that we speak: Thoughts on language and culture in the classroom. New York: New Press.

Diaz-Rico, L. T., & Weed, K. Z. (2002). The crosscultural, language, and academic development handbook. London: Allyn & Bacon.

Dukes, E. F. (1996). Resolving public conflict: Transforming community and governance. Manchester, England: Manchester University Press.

Duran, B. J. (1998). Language minority students in high school: The role of language in learning biology concepts. Science Education, 82(3), 311–341.

Duschl, R., Ellenbogan, K., & Erduran, S. (1999). Promoting argumentation in middle school science classrooms: A project SEPIA evaluation. Paper presented at the Annual Meeting of the National Association for Research in Science, Boston, MA.

Duschl, R. A., Schweingruber, H. A., & Shouse, A. W. (Eds.). (2007). Taking science to school: Learning and teaching science in grades K-8. Washington, DC: National Academies Press.

Emirbayer, M., & Mische, A. (1998). What is agency? American Journal of Sociology, 103(4), 962–1023.

Fisher, R., Ury, W., & Patton, B. (1991). Getting to YES: Negotiating agreement without giving in (2nd ed.). New York: Penguin Books.

Fiske, J. (1994). Media matters: Everyday culture and political change. Minneapolis: University of Minnesota Press.

Ford, M., & Forman, E. A. (2006). Redefining disciplinary learning in classroom contexts. Review of Research in Education, 30(1), 1–32.

Gee, J. P. (1988). Dracula, the vampire lestat, and TESOL. TESOL Quarterly, 22(2), 201–226.

Gee, J. P. (1990). Social linguistics and literacies: Ideology in discourses (2nd ed.). London: Falmer.

Goodman, J. F., Hoadland, J., Pierre-Toussaint, N., Rodriguez, C., & Sanabria, C. (2011). Working the crevices: Granting students authority in authoritarian schools. American Journal of Education, 117(3), 375–398.

Gorham, J. (1988). The relationship between verbal teacher immediacy behaviors and student learning. Communication Education, 37(1), 40–53.

Hand, B., Norton-Meier, L., Staker, J., & Bintz, J. (2009). Negotiating science: The critical role of argument in student inquiry, grades 5–10. Portsmouth, NH: Heinemann.
Hand, B., Therrien, W., & Shelley, M. (2014). Argument-based inquiry effects on science, mathematics and reading comprehension: A randomized control study. Learning and Instruction. (under review).
Hand, B., Therrien, W., Shelley, M., & Laugerman, M. (2014). Effectiveness of an inquiry-based approach on grade 5 students' critical thinking skills. Elementary School Journal. (under review).
Heath, S. B. (1983). Ways with words: Language, life, and work in communities and classrooms. Bath, England: Pittman Press.
Hildebrand, G. M. (2001). Re/writing science from the margins. In A. C. Barton & M. D. Osborne (Eds.), Teaching science in diverse settings: Marginalized discourses and classroom practice (pp. 161–199). New York.
Hodson, D. (1999). Going beyond cultural pluralism: Science education for sociopolitical action. Science Education, 83(6), 775–796.
Irvine, J. T. (1985). Status and style in language. Annual Review of Anthropology, 14, 557–581.
Irvine, J. T. (1988). Ideologies of honorific language. Pragmatics, 2(3), 251–262.
Isaacs, W. H. (1993). Taking flight: Dialogue, collective thinking, and organizational learning. Organizational Dynamics, 22(2), 24–39.
Jiménez-Aleixandre, M. P. (2007). Designing argumentation learning environments. Contemporary Trends and Issues in Science Education, 35(2), 91–115.
Koenigs, S. S., Fiedler, M. L., & Decharms, R. (1977). Teacher belief, classroom interaction and personal causation. Journal of Applied Social Pyschology, 7(2), 95–114.
Laugerman, M., Fostvedt, L., Shelley, M., Baenziger, J., Gonwa-Reeves, C., Hand, B., et al. (2013, March 7–9). Structural equation modeling of knowledge content improvement using inquiry based instruction. Interactive poster presentation at the Spring 2013 Conference of the Society for Research on Educational Effectiveness, Washington, DC.
Lax, D. A., & Sebenius, J. K. (1986). The manager as negotiator. New York: The Free Press.
Lee, O. (1997). Diversity and equity for Asian American students in science education. Science Education, 81(6), 107–122.
Lee, O., & Fradd, S. H. (1996). Literacy skills in science learning among linguistically diverse students. Science Education, 80(6), 651–671.
Lemke, J. (1990). Talking science: Language, learning and values. Norwood, NJ: Ablex.
Lewis, C., Enciso, P., & Moje, E. B. (2007) Reframing sociocultural research on literacy: Identity, agency, and power. Mahwah, NJ: Erlbaum.
Martin, A. M., & Hand, B. (2009). Factors affecting the implementation of argument in the elementary science classroom. A longitudinal case study. Research in Science Education, 39, 17–38.
Moje, E. B., Collazo, T., Carrillo, R., & Marx, R. W. (2001). "Maestro, what is 'quality'?": Language, literacy, and discourse in project-based science. Journal of Research in Science Teaching, 38(4), 469–498.
Neuman, S. B. (1996). Children engaging in storybook reading: The influence of access to print resources, opportunity, and parental interaction. Early Childhood Research Quarterly, 11, 495–513.
NGSS Lead States. (2013). Next generation science standards: For states, by states. Washington, DC: The National Academies Press.
Norton-Meier, L., Hand, B., Hockenberry, L., & Wise, K. (2008). Questions, claims, and evidence: The important place of argument in children's science writing. Portsmouth, NH: Heinemann.
Nystrand, M., Wu, L. L., Zeiser, S., & Long, D. A. (2003). Questions in time: Investigating the structure and dynamics of unfolding classroom discourse. Discourse Processes, 35(2), 135–198.
Peng, K, & Nisbett, R. E. (1999). Culture, dialectics, and reasoning about contradiction. American Psychologist, 54(9), 741–754.
Pelletier, L. G., Seguin-Levesque, C., & Legault, L. (2002). Pressure from above and pressure from below as determinants of teachers' motivation and teaching behaviors. Journal of Educational Psychology, 94, 186–196.
Purcell-Gates, V. (2007). Cultural practices of literacy: Case studies of language, literacy, social practice, and power. Mahwah, NJ: Erlbaum.
Raiffa, H. (1982). The art and science of negotiation. Cambridge, MA: Harvard University Press.
Rakow, S. J., & Bermudez, A. B. (1993). Science is "Ciencia": Meeting the needs of Hispanic American students. Science Education, 77(6), 669–683.
Reeve, J., Deci, E. L., & Ryan, R. M. (2004). Self-determination theory: A dialectical framework for understanding the sociocultural influences on student motivation. In D. McInerney & S. Van Etten (Eds.), Research on sociocultural influences on motivation and learning: Big theories revisited (Vol. 4, pp. 31–59). Greenwich, CT: Information Age.
Reeve, J., & Tseng, C. M. (2011). Agency as a fourth aspect of students' engagement during learning activities. Contemporary Educational Psychology, 36(4), 257–267.

Reznitskaya A., & Gregory, M. (2013). Student thought and classroom language: Examining the mechanisms of change in dialogic teaching. Educational Psychologist, 48(2), 114–133.

Richter, E. (2011). The effect of vocabulary on introductory microbiology instruction. Tempe: Arizona State University Press.

Rosenthal, J. W. (1993). Theory and practice: Science for undergraduates of limited English proficiency. Journal of Science Education and Technology, 2(2), 435–443.

Rossato, C. A. (2007) Engaging Paulo Freire's pedagogy of possibility: From blind to transformative optimism. New York: Rowman & Littlefield.

Schein, E. H. (1993). On dialogue, culture, and organizational learning. Organizational Dynamics, 22, 40–51.

Schoerning, E. (2014). The effect of plain-English vocabulary on student achievement and classroom culture in college science instruction. International Journal of Science and Mathematics Education, 12, 307–327.

Schoerning, E., & Hand, B. (2012). Language formality, learning environments and student achievement. In: The future of learning: Proceedings of the 10th international conference of the learning sciences (ICLS 2012) (Vol. 2, pp. 154–156). Sydney, NSW, Australia: ISLS.

Schoerning, E., & Hand, B. (2013). The discourse of argumentation. Mevlana International Journal of Education, 2(3), 43–54.

Sevinc, B. (2011). Investigation of primary students' motivation levels towards science learning. Science Education International, 22(3), 218–232.

Skinner, E. A., & Belmont, M. J. (1993). Motivation in the classroom: Reciprocal effects of teacher behavior and student engagement across the school year. Journal of Educational Psychology, 85, 571–581.

Smith, S. S., & Dixon, R. G. (1995). Literacy concepts of low- and middle-class four-year-olds entering preschool. Journal of Educational Research, 88(4), 243–253.

Susskind, L., McKearnan, S., & Thomas-Larmer, J. (1999). The consensus building handbook: A comprehensive guide to reaching agreement. Thousand Oaks, CA: Sage.

Tippett, C. (2009). Argumentation: The language of science. Journal of Elementary Science Education, 21(1), 17–25

Tobin, K., & McRobbie, C. J. (1996). Cultural myths as constraints to the enacted science curriculum. Science Education, 80, 223–241.

Tuan, H-L. (2005). The development of a questionnaire to measure students' motivation towards science learning. International Journal of Science Education, 27(6), 639–654.

Vygotsky, L. S. (1987). Thinking and speech. In R. W. Rieber & A. S. Carton (Eds.), The collected works of L. S. Vygotsky: Problems of general psychology (Vol. 1) (N. Minick, Trans.) (pp. 53–92). New York: Plenum Press. (Original work published 1934).

Zembal-Saul, C., Munford, D., Crawford, B., Friedrichsen, P., & Land, S. (2002). Scaffolding preservice science teachers' evidence-based arguments during an investigation of natural selection. Research in Science Education, 32(4), 437–463.