Promoting student engagement in science: Interaction rituals and the pursuit of a community of practice

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Interaction Rituals and the Pursuit of a Community of Practice

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Abstract

This study explores the relationship between interaction rituals, student engagement with science, and learning environments modeled on communities of practice based on an ethnographic study of an eighth grade urban magnet school classroom. It compares three interactional events in order to examine the classroom conditions and teacher practices that can foster successful interaction rituals (IRs), which are characterized by high levels of emotional energy, feelings of group membership, and sustained interest in the subject. Classroom conditions surrounding the emergence of successful IRs included mutual focus, familiar symbols and activity structures, the permissibility of some side-talk, and opportunities for physical and emotional entrainment. Sustained interest in the topic beyond the duration of the IR and an increase in students’ helping each other learn occurred more frequently when the mutual focus consisted of sciencerelated symbols, when there were low levels of risk for participants, when activities involved sufficient challenge and time, and when students were positioned as knowledgeable and competent in science. The results suggest that successful interaction rituals can foster student engagement with topics that may not have previously held interest and can contribute to students’ support of peers’ learning, thereby moving the classroom toward a community-of-practice model.
**Introduction**

The widespread use of standardized testing of public school students helps to strengthen a view of learning as an individualized activity, with the primary importance placed on transmission of information from the teacher to the student. However, learning is also a social activity, in which interaction with others is essential for students to participate in the language and practices of particular communities or disciplines (e.g., Lave & Wenger, 1991). In a socially situated perspective on learning, the incentive for acquiring new information and skills does not emerge only from intrinsic interest in the content, or from a system of rewards and punishments such as that offered by grades and testing, but also from the desire to contribute as valued members of a community. Interaction within social settings is particularly important for learning science, as science is a discursive activity involving the collective use of science-related terms and methods of argumentation in order to construct concepts, or ‘‘thematic patterns’’ (Lemke, 1990), and evaluate explanations for phenomena. Viewing learning as a social rather than as an individual pursuit has implications for approaches to classroom change in science. Rather than focusing efforts on raising students’ test scores through methods such as standardizing the curriculum to correspond with test content, more attention could be given to altering the environment of classrooms in ways that increase students’ opportunities for meaningful participation and interaction surrounding science learning.

Wenger’s (2000) conception of a ‘‘community of practice’’ offers a possible model for a classroom that could facilitate learning through social interaction. Wenger described learning as taking place within collective activity in which individuals provide scaffolding for each other to acquire the skills and knowledge for participation. In a classroom modeled on a community of practice, students would not only interact with central participants, such as the teacher, but also
with peripheral participants, such as other students at varying levels of skill. In such a view, learning involves not only developing new knowledge but also acquiring an identity associated with the group (Wenger, 2000). A vision of classrooms as potential communities of practice seems to be in contradiction to the physical setting and teacher practices of most classrooms, where students’ desks face forward and there is a heavy use of teacher-centered, initiation–response–evaluation (IRE) dialogue, which allows the teacher to retain control of the direction of classroom talk but does not facilitate interaction among the students (Lemke, 1990).

Curricular reforms that increase communication between students may be a productive step toward encouraging a ‘‘community-of-practice’’ type of classroom. However, putting students into small groups or providing opportunities for them to interact with each other in whole-class activity will not be effective if the social interactions that ensue are experienced as unsuccessful by some students, in that they are excluded rather than welcomed as participants. As an example, Kurth, Anderson, and Palincsar’s (2001) study of the interactions of one racially and ethnically diverse work group in a science class found that the contributions of a black female student were marginalized by the white students and that over time she became increasingly disconnected from the group endeavor. Although this example involved only one student in one study, it demonstrates the possibility that group work interactions may lead to exclusion and highlights the importance of attending to not only whether students have opportunities to work with each other, but also to whether the interactions that emerge are experienced by students as successful, and involve mutual support, increased participation for all students present, a desire to learn the subject, and strengthened feelings of group membership.

Collins (2004) described how feelings of group membership and interest in particular activities emerge from series or chains of what he called ‘‘successful interaction rituals’’ (IRs),
which are characterized by a build-up of mutual focus, the development of a common rhythm and mood, and, consequently, an increase in positive feelings associated with the group. Such rituals contribute to emotional energy (EE) becoming associated with the group and its symbols. It is possible that a series of such successful interactions in science classes could contribute to more of a ‘‘community-of-practice’’ type of classroom in that the IRs would foster feelings of group membership and interest in the subject. An understanding of how to facilitate successful IRs, or at least not to interfere with their development, would therefore be helpful for teachers.

Although it may not be possible for there to be a constant stream of successful IRs in a classroom given that energy levels fluctuate (Collins, 2004), some environments and activity structures may be more conducive to the development of successful IRs than others. In addition, some types of IRs may be more effective than others at stimulating feelings of membership associated with science. In this study, I focus on a case study of an eighth grade Philadelphia magnet school classroom over the 2001–2 school year in order to investigate the outcomes of microlevel interactions as they relate to group membership surrounding science. The study was conducted in cooperation with the teacher researcher, Linda Loman, and four students who served as researchers, Aileen, Ashley, Lisa, and Monique (student names have been changed). Analysis of data indicates the occurrence of both successful and unsuccessful IRs throughout the year, making possible a comparison of classroom conditions that were associated with different types of interactions. In this investigation, I address the following questions: (1) Which types of teacher practices and classroom environments facilitated successful IRs? (2) Under what conditions did such IRs contribute to longer-lasting solidarity, feelings of group membership, and interest in the subject?
Applying Collins’s framework, I describe the conditions surrounding three events that were examples of common types of successful IRs in the classroom. The first type is a one-on-one interaction between Linda and a student surrounding a hands-on lab activity. The second type is a whole-class interaction in which solidarity was built based on personal relationships, references to sports, and a shared experience making fun of the teacher. The third type is a whole-class interaction involving unfamiliar science content in which students helped each other to solve a problem at the board. In the analysis of each example, I focus on how the teacher’s practices, the physical setting, and the activity structures contributed to the generation of IRs characterized by synchrony among participants, including anticipation of others’ utterances, coordination between participants’ gestures, gaze direction and movements, and outcomes of group membership.

Based on data from this classroom, I argue that the development of feelings of group membership and identities associated with science depends not only on the content or the instructional method, which are often emphasized in research on science education, but on a variety of classroom conditions that contribute to the emergence of successful IRs and their effectiveness at investing science-related symbols and concepts with emotional energy. Such conditions include the roles that teachers and students occupy in class discussions, the relationship of participants’ contributions to ‘‘what counts’’ as knowledge, the physical setting of the classroom, the objects or symbols that serve as a mutual focus for IRs, and the membership groups that are referenced and solidified.
Theoretical Framework

Some researchers (e.g., Barton & Yang, 2000; Seiler, 2002) have argued that the content taught in urban schools does not hold relevance to the lives of students. One implication of this argument is that student interest in science would increase if the courses were changed to reflect students’ lived realities. Although relevant content may be a step toward greater equity, changing the content alone may not increase student engagement if it is not accompanied by feelings of group membership. Seiler’s (2002) ethnographic study showed how some students did not always appreciate having the content of their courses changed, either because they felt it was not ‘‘real science’’ or because they felt that the change in content did not really give them any greater power in the classroom. Both of these comments suggest that, although the teachers had attempted to include students’ cultural capital, the students still felt a sense of separateness from a group centered on science learning.

Collins (2004) offered some theoretical insights into which types of interactions might contribute to group membership and therefore learning, describing how choices of which activities to pursue and to which groups to belong are based on people’s tendencies to maximize levels of emotional energy. EE is generated through successful interaction rituals (IRs) that are characterized by bodily co-presence, mutual focus, common mood, boundaries to outsiders, an ‘‘entrainment,’’ or coordination, of body movements and speech, shared experience between participants on both an emotional and cognitive level, and solidarity with others present. His work emerged from Durkheim’s (1912/1965) writings regarding how interaction rituals solidify group ties. Although the term ‘‘ritual’’ is commonly associated with formal rituals such as religious ceremonies, Collins drew on the work of Goffman (1967) in conceptualizing ritual as
encompassing everyday interactions between people, which have ritualized components that are often enacted without awareness.

During successful IRs, the symbols that are both exchanged and created become invested with emotional energy, and can be used later to generate successful IRs with others who find these symbols similarly charged. In discussing the role of symbols, Collins drew on Durkheim’s (1912/1965) description of ‘‘sacred objects,’’ which represent the society and are treated with respect. As an example, Collins described how, after a day watching a football game among thousands of people at a stadium, the mutual focus and shared noisemaking induce a common mood that becomes more intense as the game progresses. The football players serve as symbols that become invested with emotional energy, and discussion of these players in other settings, such as at school or in the workplace, can facilitate more successful IRs. He writes that the intersubjectivity that emerges from successful IRs is similar to Durkheim’s collective consciousness, where the society or group becomes represented in the symbols. Although Durkheim wrote of symbols imbued with religious significance, one can imagine that jerseys or hats, for example, with the names of sports teams can serve as ‘‘sacred objects’’ in the sense that they represent a particular group that supports that team or lives in the city. Collins described the relevance of not only high-visibility symbols, but also ‘‘cognitions,’’ because concepts and knowledge are associated with groups, can become invested with EE, and therefore can influence people’s sense of membership.

Although one would not expect students to display as much excitement toward science as toward football, it is possible that science symbols, language, ideas, and concepts can still become invested with EE through successful IRs, and could include the lab materials, diagrams, mathematical symbols, and concepts such as ‘‘phases of the moon.’’ Students may not consider
these symbols or cognitions to be ‘‘sacred objects,’’ yet successful IRs in science classrooms may still foster group membership surrounding them. Whether students ‘‘talk science’’ is therefore related to whether they are drawn emotionally to re-invoking membership in the associated membership group, which is contingent upon past IRs surrounding science in classrooms and in other settings. Collins (2004) described how, over the course of time, series of IRs accumulate into ‘‘interaction ritual chains,’’ forming the basis of people’s feelings of membership in particular groups and interests in particular ideas. It is possible that the emotional charging of science-related symbols and concepts in a science class would not only result in feelings of group membership within the classroom, but also facilitate future participation in other groups for which science is relevant, such as doctors, gardeners, engineers, parents concerned about nutrition, or environmental activist groups.

Collins (2004) described how interaction rituals may fail when a group does not become entrained, such as in a political rally where participants listen to a poorly executed speech that does not draw the attention of the audience. Even a successful IR may not generate EE for some of the individuals present because they lack familiarity with or have negative associations with the symbols used. Although entrainment may occur for those who are engaged in the IR and find the circulating symbols emotionally charged, those who do not may lose focus and become withdrawn from the group activity. Collins indicated that experiences such as these do not lead to solidarity, fail to produce changes in identity, and may result in that individual avoiding the particular group and the associated symbols in the future. This framework can help illuminate how lack of relevance of material (e.g., Seiler, 2002), or depictions of science as too difficult for most students (e.g., Barton & Yang, 2000), can lead to exclusion on an interactional level, as there is not a shared basis of symbols for the generation of successful IRs. In addition, physical
constraints, such as large classrooms and seating arrangements that inhibit interaction among students, can pose a challenge for teachers in encouraging mutual focus, entrainment, and therefore solidarity in science.

Based on Collins’s framework, it seems that familiar content brought into a science class should be helpful in generating solidarity, as common symbols or experiences can provide a mutual focus necessary for the initiation of IRs. In the eighth grade classroom of this study, physics problems that incorporated sports figures, movies, or television shows generated more focused concentration, laughter, attunement to each other’s movements, and student contributions to the discussion than problems that only used canonical science language. However, the types of symbols that involve the entire class, such as public figures, may be too widely available to produce solidarity that lasts longer than the duration of the particular problem, or may not be associated with strong emotional experiences. Collins (2004) discussed how commonly known symbols are not sufficient to cement ties because they do not help people differentiate others or establish boundaries. Alternatively, familiar content that is less widely available, such as hobbies, may not apply to the whole class and may create divisions. For example, students who share a teacher’s interest in discussing scuba diving will be the only “insiders” if knowledge of diving is important to successful participation in a teacher-led discussion about water pressure. It seems that it would be important for new successful rituals surrounding science content to be created that involve the classroom as a unit, in order to meet the characteristic of interaction rituals having boundaries, with the group members inside.

It is important to note that most schools offer grades and teachers offer praise, which may contribute to increased levels of EE for some students. However, although these interactions may generate solidarity between the teacher and student involved, the distribution of grades and
praise to some and not to other students may decrease solidarity of the group as a whole. Some students in the eighth grade classroom involved in this study described how they felt they were not respected and were considered to ‘‘not belong’’ in the magnet school if they did not maintain good grades. Several of them explained that the situation was unfair because they had come into the school with less academic background in the subjects than many of the other students and did not receive support from the school. The tendency of individuals to maximize EE provides one perspective on why some students who are unsuccessful at obtaining good grades sometimes try to draw attention away from the teacher, making remarks that get the class to laugh. Such actions would at least enable the student to experience solidarity with other students, and can provide an alternative IR to the one from which that student feels excluded. For students to identify themselves as members of a group focused on the teaching and learning of science, it seems important for the science classroom to involve rituals that generate solidarity among the entire class, rather than just between the teacher and the high-achieving students.

Collins (2004) described how youth have not yet developed symbolic memberships from work experiences, and they sometimes seek entrainment through extensive time spent talking about public figures. However, it is possible that science class could serve as a basis for a work type of membership if successful rituals could enable students to begin associating science terms and procedures with EE and contribute to feelings of group membership within a classroom science community. Although it is likely that some students have had negative experiences with science, just as it is possible for highly successful IRs to produce new symbols (Collins, 2004), such IRs may also be able to change participants’ previous negative associations with particular symbols related to science.
I do not wish to imply that a science-related identity is an end product, as identity is at once a product and an input in interactions. Successful IRs can lead to changes in identity, but if students already identify somewhat with a group centered on science, they will be more likely to be able to initiate or participate in successful IRs in science classes. A student’s sense of group membership in science is not decided in some final way, but is in a state of constant flux, which on the microlevel is influenced by conditions that include stores of relevant symbols, emotional energy, and classroom conditions.

The Classroom

City Magnet is an academic magnet school for grades 5–12. Students come from diverse ethnic, racial, and socioeconomic backgrounds. Students are selected from schools throughout the city to attend the middle school based on their grade 3 test scores and grades. However, many families do not know how to apply to the school or if their child is eligible to apply. In their grade 8, City Magnet students submit applications for high schools and are chosen for admission based on their grades in grade 7, behavior marks, attendance record, and scores on standardized tests. Only about 100 of the 200 grade 8 students will be selected to enter the more prestigious high school, housed in the same building. The remaining students either attend other magnet schools, private schools, or neighborhood schools. In the grade 8 classroom that is the setting for this study, students described the tension they experience in trying to prove to their teachers and other students that they really belong there, because half of them will not be accepted into the high school for the following year.
The grade 8 classroom that is the focus of this study had 33 students. Of these, approximately 40% were white, 34% were black, 10% were Asian-American, 10% were Hispanic, and 6% were multiracial. Some of these students came to City Magnet from private schools, some from elementary schools in middle-class neighborhoods, and some from elementary schools in low-income, predominantly black neighborhoods. There were large variations in academic performance among these students, tending to correspond with whether or not they attended elementary school in a high-poverty area of the city.

The students sat in six rows facing the front of the room. The classroom had no sinks or lab materials, and the teacher needed to bring in materials herself when she wanted the students to do a lab or hands-on activity at their desks. The class activities were divided between teacher-led introduction and review of concepts and problem-solving techniques, hands-on activities, and group projects. The grade 8 science curriculum is divided into trimesters of physics and chemistry and earth science, in that order, for this particular section of grade 8. The teacher, Linda, is a certified high school physics teacher who has only taken one semester of chemistry and has little background in earth science. She was therefore out of her field when she taught both chemistry and earth science.

There were quite a few challenges to developing a community of practice in the classroom, such as the competitive nature of the school choice process and a lack of opportunities for peripheral participation that students could consider meaningful and relatively free of risk. Many students described how they were afraid to offer ideas or ask questions because they were concerned about the teacher thinking that they were “stupid” or because they might receive negative comments from peers.
Methods

In this study, I employed an ethnographic approach framed by Guba and Lincoln (1989), who developed criteria for authenticity that include working with participants toward positive change and increasing their understanding of each other’s perspectives. Toward this end, I have been conducting the research in collaboration with Linda, who served as a teacher researcher, and four student researchers from the classroom. All four of the student researchers are girls who had come to City Magnet from neighborhood elementary schools. Ashley, Aileen, and Monique are black, and Lisa’s father is white and her mother is black. Linda is white, in her late 20s, and came to this city from New Mexico.

During the 2001–2 school year, I was a participant-observer in the classroom, videotaping classes, taking field notes, leading research meetings, having informal conversations with students, sometimes coteaching, and leading a weekly science review session. Data were collected in the form of field notes, student work, interviews, and video- and audiotapes of classes. During the school year, through co-generative dialogues (Roth, Tobin, Zimmermann, Bryant, & Davis, 2002), the research team discussed issues that were of concern to the students and teacher, reviewed videotapes of class, and examined salient incidents involving teaching and learning. The student researchers interviewed other students about science learning and their interactions with the teacher and with the other students. The interviews and research meetings with the students were transcribed and analyzed for emergent themes.

During research meetings that continue to take place, the team has been conducting analyses of videotapes of class sessions, comparing differences in teaching and learning across topics, activities, and whether Linda was teaching in or out of her field of expertise. In my own analyses, I have specifically focused on the microlevel of interactions in order to look for
evidence of successful and unsuccessful interaction rituals, including an examination of
dialogue, body language, gaze direction, rhythm of speaking, gestures, and synchrony or
asynchrony in movements and facial expressions. By slowing videos to the tenth of a second, I
observed when students’ movements and gaze direction became coordinated, which provides
evidence regarding the development of mutual focus and common rhythm. By transcribing and
analyzing some of the classroom dialogue, I have examined patterns involving whether talk was
characterized by overlap, pauses, interruptions, changes in volume, participants finishing each
other’s sentences, and synchronous or asynchronous timing between the ending of one
participant’s utterance and the beginning of another’s. Although coordination and anticipation of
others’ movements and utterances provides evidence of the build-up of entrainment and
solidarity, lack of coordination, such as pauses, hesitation, and asynchronous movement, suggest
a lack of entrainment.

In order to investigate solidarity in the classroom, I compared the participation of
students across activities, topics, and over time, counting how frequently students made negative
comments, supported each other’s learning, and asked questions. I also examined the conditions
surrounding when interaction rituals occurred and distinguished between rituals that led to
momentary solidarity and those that led to longer-lasting associations of particular symbols with
EE. Analysis of the possible longer-term influences of IRs was based on interview data, student
work, observations of class sessions, the teacher’s assessment, self-reporting, and dialogue
between students and teachers. For example, students’ comments about the subject content, the
activities, the teacher, other students in the class, and the class environment were helpful in
assessing the levels of EE that the students associated with particular activities or topics. I also
compared the participation of students of different educational backgrounds, prior achievement, gender, and race.

Although there were many successful IRs (as well as unsuccessful IRs) that occurred over the course of the year, in this study I compare three incidents that serve as examples of different types. I selected these IRs initially based on microanalysis of participants’ movements and vocalizations. However, successful IRs are not only identifiable on the microlevel, as participants should have a conscious awareness of emerging from a successful IR feeling energized and positive about the activity and the group. Participants may not be able to describe whether, for example, their movements were coordinated with those of others. However, they may describe an event as a good speech, a stimulating conversation, a good game, or an enjoyable class. Part of our methodology therefore included having the student and teacher researchers review videotapes of classroom events and describe how they felt about the class, the topic, and the other participants. Identification of successful IRs at the microlevel was compared with the student and teacher researchers’ descriptions of interactions at the level of everyday experiences in order to determine whether there were coherences and/or contradictions. The students and teacher confirmed the assessment of the three vignettes in this investigation as successful IRs by identifying them without being prompted as “good teaching,” “engaging,” “fun,” or other such positive ratings. As should be expected, the microanalysis of events generally cohered with participants’ reporting of their subjective experiences.

The classroom study extended throughout the 2001–2 school year. However, the study also involved a longitudinal investigation of the interest in science and school experiences of the four student researchers over the following 2 years. Through sustained interaction with the
student researchers, I explored how their interests in particular science topics and their identities related to science developed over time.

**Successful Rituals**

*Individualized Instruction Surrounding Lab Materials*

On a November day, the students worked in pairs to design machines made from Lego kits that contained materials and written instructions for constructing levers, pulleys, windmills, and other types of machines. Students were then expected to create a series of tests or experiments for their classmates to perform on their machines based on their understanding of concepts such as force and work. James and Nina built a machine whereby, turning a handle, a ‘‘windmill’’ spun. However, after they constructed the windmill, they sat without talking, apparently unsure how to proceed with the next step of creating the instructions for an experiment for their peers to conduct. Linda came over to help this group.

When Linda arrived, James was turning the handle continually, watching the windmill spin as he did so. Nina was watching the windmill but was not touching the object. Linda knelt down so that her head was at James’s level and touched the windmill.

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### Key
- Underline for emphasis
- : stretched out sound
- ||Bounds overlapping talk
- . . . pause (.20) timed pause

<table>
<thead>
<tr>
<th>Speaker</th>
<th>Sp</th>
<th>Talk</th>
<th>Physical Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linda</td>
<td></td>
<td>What happens if you move this.. if you move this in . . . AARRGH .. a little closer, easier or harder?</td>
<td>Linda places her hands on the windmill to adjust a piece. James does not remove his hands. Linda leaves one hand on the object when she finishes</td>
</tr>
<tr>
<td>James</td>
<td></td>
<td>Easier . . . much</td>
<td>James continues to spin the windmill and does not look at Linda.</td>
</tr>
<tr>
<td>Linda</td>
<td></td>
<td>Ok you see how you can (inaud) you can change how far away you are from the center. It also tests how much work you are doing by seeing how heavy the thing is that you are lifting.</td>
<td>Linda moves her hand to a different part of the base of the object and uses her other hand to point. James does not remove his hands from the windmill and keeps spinning. A few seconds go by, and James gives two small nods, but</td>
</tr>
</tbody>
</table>
James: how far up you lift it.. James: how far up (you lift it) does not stop his spinning nor look at Linda.
Linda: Oh! Linda looks at James. James looks at Linda and they share a glance for a moment.
James: And how far up you push on it Whooo! This is fun James looks at the camera.
Good idea. Both of James’s hands and one of Linda’s remain on the windmill.
Alright.. now.. pull that out. OK show Nina. James’s two hands are on the windmill and Linda places one hand on the windmill to show James what to pull out.
AAARRGH. James makes an exaggerated face of frustration, with an open mouth and squinting eyes.

For most of the time during this interaction, both James and Linda had at least one hand touching the machine. Their hand movements were slow and seemed coordinated, with no fumbling even though they were in close proximity and jointly manipulating a small object. Their head nods occurred practically simultaneously. There did not seem to be a dispute over control of the object, but rather a synchrony and entrainment as they worked within shared space.

In the beginning of the interaction, it seemed like James was not paying attention to what Linda was saying, because he remained staring at the object and did not respond vocally or glance in her direction. However, their vocalizations became synchronous over time as well. Linda’s “AARRGH,” uttered in the beginning of the interaction when she tried to move the handle, was acquired by James when in an exaggerated matter when he also tried to do the same task at the end. Although there is a time delay between the “AARRGHs,” it suggests not only coordinated body language, but also shared noisemaking and James’s use of a sound that Linda introduced. However, much more importantly for science teaching, the scientific explanation for the change in the amount of effort it took for James to turn the handle was also coordinated, with James anticipating what Linda was going to say about the topic. When he did so, saying “how far up you lift it,” she uttered a surprised, “Oh!” and they shared a glance. The synchrony of movement and of noisemaking was reflected in synchrony in providing a science-related
explanation. James was obviously paying attention to her words, as he was able to anticipate what she was going to say.

In science education reform there is a continual issue of how to integrate hands-on and lab activities with science content. Some science educators have criticized labs for being ‘‘cookbook’’ activities, offering students systematic instructions yet not providing a bridge to the science discourse or concepts. Interviews with the students in this class suggest that, for them, the labs and the related science concepts do often seem like separate entities, as many have said that they like the hands-on activities but they did not enjoy and were not good at science. Other education researchers (e.g., Tobin, 2005) argued that it does not always matter if students make immediate connections to science discourse and argument, because at least in the labs the students gain some experience ‘‘doing’’ science. This particular interaction between James and Linda suggests that hands-on activities are not just important because they are inherently more interesting than listening to a lecture, but also because they contain physical materials that allow for a mutual focus to develop that can serve as the basis for an IR characterized by entrainment and exchange of symbols and cultural capital between teacher and student.

Interaction surrounding lab materials may also lead to more entrainment than lecture because of the greater value placed on students’ contributions. Collins writes that a successful IR should have inputs of both emotional energy and cultural capital, which are outcomes of previous IRs recirculated into generating new IRs. In IRE lecture, the teacher generally provides almost all of the cultural capital, and the students give one-word answers (Lemke, 1990). Often, these do not draw on the students’ own experiences, but involve completing the thoughts of the teacher, such as answering the question, ‘‘What is the unit for velocity?’’ However, in individualized instruction surrounding lab materials, students’ ideas are welcome and necessary
inputs. In the vignette, James provided evidence from his direct experience with the machine and newly acquired knowledge about the science concepts, while Linda assisted him with developing a set of constructs for evaluating and testing the machine. Both of the interactants provided necessary cultural capital and emotional energy. Labs may sometimes be relatively ineffective at facilitating connections with the science content because the teacher does not have time to interact with all of the students, and the students may not have enough stores of cultural capital to initiate successful, science-centered IRs surrounding the materials. The student researchers identified this vignette as an example of good teaching, because, as Ashley described, ‘‘most teachers do not take the time to work one-on-one with us.’’

An educator might view this vignette as a good example of scaffolding (e.g., Vygotsky, 1978), as the teacher’s comments and actions provided a bridge for the students’ understanding and use of the concepts. However, attempts at providing scaffolding for students are not always successful, as the teacher and students may not be able to communicate with each other well enough for this ‘‘bridge’’ to be built. Students in this class described how sometimes they prefer to listen to other students because the teacher’s vocabulary is too advanced for them. It is likely that this vignette facilitated scaffolding because of its success as an IR, as there was sufficient time for participants to interact with the object, share a mutual focus, coordinate their movements, and build intersubjectivity in both emotional and cognitive domains. This type of lab may already have been associated with EE for students, as many students played with Lego when they were younger, and they enjoy working with their peers. However, in this instance, the EE seemed to transfer from the activity itself to the use of scientific terms and explanations, as James discussed the ideas willingly and described the activity as ‘‘fun.’’
One important question is whether experiences such as this one invoke membership in a science community in the long term. In this case we do not see the long-term results for James, but we do see him using the science discourse in the next segment as he explains the idea to Nina and works with her in designing the experiments, which is some evidence for the beginnings of group membership associated with science. Exchanges such as this one can contribute to the classroom becoming more like a “community of practice,” where peripheral participants have the important role of helping others become enculturated into the language and methods of science.

Although this incident serves as an example of how teachers could initiate successful IRs focused on science learning, it is not feasible to depend on such interactions to solidify group membership and interest in science given that the size of most classrooms does not allow for extensive one-on-one interaction between teacher and students. Many teachers see whole-class interaction as the most efficient approach to address the mandated science curriculum in a limited time period to a large class (e.g., Lemke, 1990). Thus, efforts need to be made to understand how to foster the types of interactions that would stimulate feelings of group membership within a variety of instructional contexts, including whole-class activity. These next two examples address the potential for successful interaction rituals to emerge in whole-class interaction.

Whole-Class Rituals—McNabb Vignette

In some ways, whole-class activity structures have the potential to be conducive to successful IRs surrounding science, as they entail the assembly of a large group of students who can become entrained in each other’s movements, voices, and emotions. However, in other ways,
whole-class interactions are a much more challenging situation for IRs than small group work or individualized instruction, as there is a greater risk of students’ experiencing shame from using science language incorrectly, which can prevent the language of science becoming associated with EE. In addition, whole-class activity often takes place in the form of IRE dialogue, in which teachers may consider students interacting with each other to be distracting and therefore discourage them from doing so (Lemke, 1990).

Despite the constraints posed by whole-class interaction, analysis of videotapes, and discussions with the teacher and student researchers indicate that this eighth grade classroom had some successful IRs in whole-class interaction. In the first type that I describe, Linda discussed interests that she and the students had in common, such as sports, food, religion, or popular movies. Such topics can be thought of as cultural capital, as they entail forms of knowledge and signify membership in particular groups. Linda explained that she bases her approach, which she described as ‘‘making science more relevant,’’ on her belief that the use of examples from the students’ life-worlds demonstrates to them that the knowledge they possess and the knowledge that she offers to them through science teaching are in some ways commensurate. However, this strategy is not ‘‘cultural relevance’’ in the sense that Seiler (2002) and Barton (2001) recommended, as Linda still adhered to the standard science curriculum without questioning what types of knowledge count as science.

In this vignette, which took place toward the end of the physics unit, Linda was demonstrating momentum problems for students on the board using a sketch of the quarterback for the Philadelphia Eagles:

Key
- Underline for emphasis
- : stretched out sound
- ||Bounds overlapping talk
- . . . pause (.20)
- timed pause
In the beginning of the clip, Linda said, ‘‘Here we have . . .,’’ and students’ talk was uncoordinated and unfocused as they held small conversations amongst themselves. However, as soon as Aileen said, ‘‘Why is his legs broken,’’ the students laughed loudly and simultaneously. As the talk progressed, the students’ comments became well-coordinated and focused on the main activity as they provided simultaneous utterances, such as ‘‘Ew . . . Warren Sapp,’’ and engaged in punctuated, rhythmic laughter. Over the course of the vignette the laughter changed in tone and volume, starting out as giggles, which I wrote as ‘‘he he he’’ to more ‘‘musical’’-
sounding laughter (ha ha ha) to louder laughter (HA HA HA), then back to the giggles. The
coordinated comments and changes in volume and tone of the laughter suggest a build-up of
entrainment over time. The interaction resembled a collective conversation rather than an IRE
dialogue, as students’ responses were voluntary, spontaneous, and overlapping. The mutual focus
was the drawing on the board, and shared symbols included Linda’s poor artistic abilities and the
‘‘sad’’ player from Tampa Bay.

The success of this IR was partly facilitated by Linda’s willingness to allow some student
side-talk rather than maintaining a silent classroom, as this allowed for students to become
entrained in each other’s voices. It was also successful because the content drew on symbols and
membership groups that had previously been invested with EE for the students. One group is that
of Philadelphia sports fans, with the relevant symbols consisting of Donovan McNabb, Warren
Sapp, and Philadelphia (as a superior city to Tampa). The other membership group is students
who generally enjoy making fun of their teachers. Although these students have had much
experience in other classes ridiculing their teachers’ actions in ‘‘backstage’’ types of
performances (Goffman, 1959), in Linda’s class they were permitted to do so with the teacher’s
awareness. Through this type of interaction, they were able to build solidarity with each other
and with the teacher, who the student researchers described as ‘‘cool’’ for having a sense of
humor and for acknowledging that she is not good at everything. Even the students who were not
interested in sports were able to participate in this IR, because all students could observe and
mock Linda’s drawing. Linda described her thoughts on the video clip:

The students love to comment about the terrible quality of my pictures and I often point out that drawing was never my
strong point. Drawing stick figures of characters is a tried and true technique for student interaction. Very rarely do the
students have the opportunity to tease a teacher in a way that is appropriate. With their peers they are able to be
lighthearted about silly subjects but rarely is science portrayed as silly. My stick figure drawings allow students the
agency to ‘‘grade’’ my pictures and gain social capital with their peers with their clever comments. I allow this and
model to students that there are things I am good at and some that I struggle with. My other goal is that they will enjoy
the problem enough to persevere through the math that some of them do not enjoy.
The student researchers who watched this vignette described how they appreciate classroom incidents such as this one because they like when Linda makes efforts to talk about things that interest them, in this case sports. Overall, it seems that the solidarity that students had previously experienced in other settings talking about sports or teachers, combined with the ability to speak and laugh freely, contributed to the emergence of a common mood among participants.

Although there was strong evidence of solidarity during this particular part of the problem, as soon as Linda began the math to calculate the momentum of the players there was a perceptible change. Students began shifting in their seats, and several of them turned away from the board. They did not call out parts of the problem in the same the way that they called out comments about Warren Sapp. Linda reverted to IRE dialogue, soliciting responses one at a time to provide answers to questions such as “What units are we using?” Linda’s speaking was rhythmic, with repeated words and dramatic pauses, but the students’ responses did not match her utterances in tone or pitch. However, most of the students were able to provide the correct answers.

The comments of student researchers when watching the video clip affirmed my observations that entrainment and solidarity dissipated as soon as the math began, as they described how they “stopped paying attention” and how they do not like doing these kinds of problems. Although Linda felt that using sports could help engage students more in science, the student researchers were in general agreement that this particular incident did not make them feel any closer to science and was more like a break from the science. Ashley described Linda’s use of McNabb in the example, “It’s the same science. She could use stick figures, it doesn’t matter. It may help us to remember it though.” Ashley’s statement suggests that she saw the boundaries
between science and other membership groups as more rigid than perhaps Linda was intending. Other students’ statements supported this view, such as Lisa’s, “It’s not really science, it’s just stuff to help us learn it.” Science seems to be viewed as a type of “sacred object,” yet with boundaries that make it difficult for students to access. Whereas the McNabb interaction resulted in solidarity among the classroom participants and a strengthening of students’ sense of membership as Philadelphia sports fans, it did not seem to have created new symbols related to science or invested science language and procedures with EE.

A question with implications for pedagogical approaches in science is why the solidarity that developed in a problem centered on sports failed to lead to EE becoming associated with the physics concepts overall. One possibility is that low levels of EE associated with math, developed during previous unsuccessful IRs in math and science classes, posed a significant obstacle to the generation of successful IRs surrounding solving these types of problems in Linda’s class. If prior negative associations were sufficiently powerful to prevent EE from transferring to the science language and procedures, this calls into question whether “making science more relevant,” such as by discussing sports or other emotionally charged symbols, is a reliably effective strategy for building solidarity surrounding science.

However, it is doubtful that students’ attitudes toward math were the only obstacle, or even the primary obstacle, affecting the persistence of solidarity and entrainment throughout the duration of the problem. Some students in the class liked math. In addition, there was evidence of entrainment associated with math among most of the students earlier in this class period when Linda asked them to describe the order of the metric units, which the students called out using a mnemonic device that Linda had previously taught them. Further, almost all of the students seemed to know the answers to the particular math-related questions Linda asked during the
McNabb problem, so answering these questions should not have been a particularly embarrassing experience for them. Although some students’ prior negative experiences with math may have been a contributing factor, it cannot suffice as an explanation for the lack of entrainment during the math section of the problem.

Another issue that seemed to have an impact on the persistence of mutual focus, entrainment, and solidarity was that most of the cultural capital in the McNabb problem was supplied by the teacher. Although students were able to provide short answers to questions in the IRE dialogue, Linda was clearly the expert and the students were either in an audience role or were being tested in their ability to supply the specific terms and facts that Linda sought. Three of the student researchers described how they do not like to give short, factual answers, due to the risk of being wrong. They explained that even answering a question correctly will not gain them respect because their peers can tell if a question is easy (see Olitsky, 2005). These and other comments suggest that short-answer questions in general have the potential to lead to a loss in EE for the students, and therefore a loss in EE associated with the activity.

However, the students described how they were able to gain respect from their peers, and therefore enjoyed classroom interactions more, when they answered questions that were open ended, that drew on their own experiences, and/or that supplied information that other classmates did not know. Their comments imply that influencing their perception of the success of particular interactions is whether they believe their own experiences and contributions were valued in the classroom community—in other words, whether or not they feel they have opportunities to act as legitimate peripheral participants. Because successful IRs require inputs of cultural capital, it makes sense that these IRs are less likely to develop or persist if students do not feel that the capital that they provide is significant or unique. Another factor inhibiting entrainment may have
been the reliance on IRE during the math section, during which interactions between the students were limited to quiet side-talk or shared glances, which were not conducive to the development of solidarity encapsulating the whole class. It is not surprising that students considered the ‘‘McNabb’’ vignette a welcome relief from the general classroom discourse, because they were able to build entrainment with each other as a group.

It is understandable that teachers, who are expected by their administrators and colleagues to maintain order, do not desire noisy classrooms. Yet classrooms where side-talk is completely prohibited may fail to encourage feelings of group membership associated with science, not only because such a restriction can prevent entrainment from developing, but because students are unable to ask each other questions that they feel are too simple or too irrelevant to ask the teacher (Lemke, 1990). If students cannot speak with other peripheral participants, the development of a community surrounding science discourse is inhibited.

Still another issue may have been the timing of the introduction of symbols associated with science. In the windmill vignette, James and Linda discussed science concepts as they conducted a hands-on activity with Lego, which students found entraining. However, in the McNabb problem, the laughter associated with sports talk and with making fun of Linda’s drawing occurred before Linda began discussing the math and physics, rather than all of these activities taking place at once. There was little student interaction centered on both sports and science at the same time, other than naming a slow velocity for the Tampa Bay player.

Many teachers draw on content that is familiar to students and, like Linda, they may use humor and symbols invested with EE in order to initiate successful IRs. Although such events are desirable because they help build social ties between teacher and students, an important question is the contributions of these IRs to the long-term development of students’ identities.
related to science. Certainly the path from a particular classroom IR to a student’s eventual choices is complex with regard to college major, career, conversation topics among friends, and newspaper articles to read. Drawing on IR theory, such outcomes can be thought of as the products of numerous interactions in a variety of settings, which means that claims regarding the effects of singular IR events are difficult to prove. However, interviews and classroom observations can provide some data on whether particular activities became invested with EE for the students over the course of the semester.

In interviews and conversations about their enjoyment and interest in different topics and activities, the activities associated with the McNabb vignette, such as doing momentum problems, were not described in positive ways. There also did not seem to be a climate of students helping each other with these types of problems. Students sometimes asked each other questions about solving the problems, but mostly it was only the several highest-performing students whose help was solicited rather than most students supporting each other. It seems that IRs such as this one were effective at building social ties and solidifying students’ interest in sports. However, these IRs did not seem to lead to the exchange of symbols surrounding science, the transfer of EE to science-related discourse and procedures, or the development of a work-type membership group specifically centered on the practice of science. Although students may seek out future IRs with this teacher, with these peers, and with groups such as sports fans, they may not be particularly drawn to interactions that involve the corresponding science discourse and procedures.

*Whole Class—Balancing Equations Vignette*
Student descriptions of the momentum problems contrast with their descriptions of balancing equations problems, which they learned to do during the chemistry trimester that began in the winter. The students showed enthusiasm for balancing equations and described the activity as “fun,” even though balancing equations is a chemistry topic that contains low levels of relevance to students’ lives outside of the classroom. While some topics in chemistry, such as acids and bases, are familiar and accessible to students, the study of balancing equations involves learning about chemical interactions at the atomic level, which is more abstract. In balancing equations, students are given a chemical reaction, such as \( \text{H}_2\text{O}_2 \Rightarrow \text{H}_2\text{O} \), and have to rewrite the equation so that there are the same quantities of atoms on the reactant side as on the product side, changing the equation to \( 2\text{H}_2\text{O}_2 \Rightarrow 2\text{H}_2\text{O} \). Some equations are complex, making this a difficult process for students, particularly those who have trouble with math. Although Linda was out of field for chemistry, she had an effective method of teaching students to balance equations, involving creating two columns and tallying up the amounts of each element in a left-hand column to represent the reactants, and a right-hand column to represent the products.

Often, during classroom balancing equation activities, Linda would have students come to the board to do problems as the other students watched. There were many successful IRs during these occasions, with students attuned to events at the board and with coordinated vocalizations and body language. The entrainment that developed during these events was surprising because balancing equations was not a topic that had previously been associated with EE for the students. It contained elements of activities that students often considered boring, such as watching other students do problems on the board, using math skills, and learning content that they did not use in their daily lives. In interviews, the students described how they considered
demonstrations and laboratories to be the most engaging types of science activities, yet balancing equations did not involve either of these types of activities.

In this section, I describe one good example of an IR surrounding balancing equations. On January 10 at 10:00, Linda wrote a problem on the board, and called on Anita to attempt a solution. The equation was $C_6H_6 + O_2 \rightarrow CO_2 + H_2O$. Anita began the problem while most of the students either looked at the board or did the problem at their seats. Linda moved to the side of the room, leaned against the door, and watched Anita. For the first 30 seconds, there was a low murmur of voices, with students speaking in even tones. Some of the students were turned around in their seats, facing others behind them. Although we did not have microphones on the student desks, some of the words were audible from the videotape, and it is apparent that they were engaged in solving the problem at their seats, because the words include numbers and instructions, such as ‘‘write it there.’’ The student researchers watching the videotape also confirmed that most side-talk was focused on the problem. Linda worked with one of the students whose desk was by the door. The voices began to get louder, with comments like ‘‘Oh yeah’’ ‘‘no you have to do it this way.’’ At 10:01:31, some higher-pitched voices were heard saying, ‘‘Whaa:t?’’ and Linda turned her head toward the board.

All but one of the students who had previously been facing students behind them turned to face the board. After the ‘‘wha:at,’’ the students’ gaze direction, head nods, and the volume of their voices became more coordinated with each other. A few students began to speak more loudly to Anita, rather than to each other, ‘‘Wait don’t erase it, ‘‘I know we’re confusing . . . ’’ ‘‘You should have kept it, you should have kept it.’’ In response to the louder voices, Linda said, ‘‘Shhhh,’’ but students kept talking. Following is a transcription of what occurred next, as James raised his hand.
Interspersed with the main dialogue shown above was quiet talk among the other students. Collins (2004) described “mutual entrainment in noisemaking” that occurs during successful New Year celebrations. I would argue that, similarly, in this classroom the student comments were related to their entrainment as they became attuned to each other’s voices and gestures and felt more a part of the group. Unlike some days, where off-task side-talk turned into a chaotic babble of voices, during this problem there was a steady, slow increase in volume as more students began making statements about the problem. Their speaking did not have much utilitarian purpose, as Anita could not hear them and they would not get praise from the teacher. They did not even attempt to be loud enough to be heard. One possibility is that part of what drove their speaking was achieving solidarity with the class through collective, audible
engagement, rather than having their contribution acknowledged. As Ashley, a student researcher, described, ‘‘We were in it together.’’

It was a long problem, but unlike other occasions, such as when demonstrations had failed, there was little stirring in the seats, coughing, or other types of asynchronous noisemaking. Collins wrote that, although entrainment can emerge from noises such as cheering that are made together and increase in frequency, volume, and coordination, some kinds of noises, such as coughs and shifting papers, are largely individual, sporadic actions, do not become coordinated among participants, and do not lead to entrainment.

Instead, the students’ gaze was toward the board and students were either quiet or making comments related to the problem. Anita also did not show signs of discomfort or awkwardness at having her classmates watch her struggle with the equation. She did not shift in place, giggle nervously, or demonstrate signs of emotional disturbance, which Goffman (1967) described as including sweating, blushing, or fumbling. She just continued to write and cross-out numbers, following other students’ suggestions.

The applause at the end of the problem started a fraction of a second before Linda said, ‘‘there you go.’’ The applause began loudly and abruptly and was dense rather than sparse. As Linda went to the board and Anita sat down, the applause became quieter, with several more spurts of dense applause before ending. Linda did not clap, and later said that she had never introduced clapping as a behavior in her class. Applause that involved almost all of the students had not occurred in this classroom before the balancing equations section of the chemistry unit. Therefore, the applause could be thought of as developing ‘‘naturally’’ in that it was not imposed by the teacher.
One possibility to explain the spontaneous development of applause is that the balancing equations activity had some of the characteristics of rituals that students associated with applause, such as sports events where audience members collectively cheer for the winner. However, in a stadium, the audience supports celebrity players without needing to know how to play the sport themselves. In this classroom, the students at the seats were learning the same procedures as Anita and held the same status. The classroom ritual may be more similar to a group of people watching a game show such as Jeopardy, calling out answers together and cheering when the contestant succeeds, especially when their advice seems to have been followed. However, an important difference was that some of the students were able to influence the outcome of the ‘‘game’’ by providing their ideas to Anita. I interpret the applause at the end as being not only for Anita, but also for the class as a whole, resulting from participation in a solidarity-building, problem-solving activity.

Collins described how, in successful rallies, the audience can anticipate the times that call for applause, and will start clapping before the punch-line. In this case, the clapping came immediately before Linda’s comments and before Anita sat down. Of course, the students could see the problem was about to end because they had been following the procedure. However, it is unusual for applause to occur in a classroom at all, and the applause did not have to be so sudden or well coordinated. I would argue that students had become entrained resulting from their collective focus on Anita at the board and their monitoring of each other’s voices and physical movements.

Throughout the chemistry unit, the interaction ritual of support and applause was carried out in the classroom with varying levels of success. In several other instances during that same class period, students gave quieter, sporadic applause, the applause did not start simultaneously
with the end of the problem, and fewer students offered helpful comments. One commonality of these “failed rituals” was that the problem was easy and the student at the board solved it quickly. For example, when Kris was balancing an equation, several students spoke to offer help, but when he solved the problem a few seconds after they made their suggestions, only three students clapped, and Linda prodded the class with, “Give Kris a hand,” because once she saw students were clapping for each other, she did not want some of the students to be left out. Both Ashley and Aileen, while watching several of these balancing equations videos, said that they felt that students were more engaged with the problems that were challenging. The perfunctory enactment of the applause ritual during the easier problems can be seen as occurring partially because the students did not have as much opportunity to build solidarity as they helped their classmates, which resulted in less time to become entrained in each other’s movements, voices, and gestures.

The successful rituals seemed to have several important components. The students attended to the problem and their classmate at the board, tracking the problem-solving strategies. They quietly asked questions or made helpful comments, particularly when the student was encountering difficulty. Rather than displaying their knowledge in the form of an answer to Anita’s problem, which would have ended the ritual, the students gave helpful comments and asked questions as Anita solved the problem herself at the board, prolonging the ritual. The students also showed greater support for each other than was typical in this class, in ways other than applauding for each other. For example, Angela and Shelly frequently argued, but in this instance they were helpful and polite toward each other.

In some ways, the classroom seemed closer to the ideal of a “community of practice,” as students were supportive and valued each other’s contributions. Students of varying levels of
performance in science provided advice throughout these problems, rather than the more
common behavior in this classroom of students only giving advice if they held the highest grades
and therefore could be more confident that others would respect their ideas. In this particular
problem, Anita was a higher-achieving student than either Angela or James, yet both of these
students felt comfortable during this unit acting as ‘‘experts.’’ Although students in the class had
previously demonstrated reluctance to speak for fear of being wrong, in the incident just
described students were willing to contribute their ideas even if they had not yet solved the 50
OLITSKY problem correctly. Angela’s ‘‘Oh ye:ah . . . Thank you’’ to Shelly demonstrates that
there was little shame in her having made an incorrect statement. Overall, the rituals that
developed surrounding balancing equations in support of a peer at the board generated solidarity
in this group of 33 students, some of whom had described how their science learning had
previously not often been supported by peers in whole-class interaction. In some ways these
balancing equations rituals were similar to the whole-class rituals centered on sports or other
aspects of popular culture, such as the McNabb vignette, as they provided a mutual focus and led
to entrainment. However, in many other ways the balancing equations IRs differed from rituals
such as the McNabb example. Rather than dissipating once the successful interactions had been
completed, as occurred in the McNabb example, the EE generated during the balancing
equations interactions persisted into students’ individual work. Students would show enthusiasm
for balancing equations not only when they were able to interact as a group, but also even on
tests or quizzes. While often the students would give collective groans in response to Linda
proposing certain activities, such as ‘‘warm-up’’ math-related questions that students were
expected to solve individually at their desks in the beginning of the period, balancing equations
‘‘warm-ups’’ received collective, although quiet, ‘‘yeah’’ responses. In addition, unlike in the
McNabb example, when entrainment would arise when sports was discussed and dissipate when the science was discussed, in the balancing equations class, the levels of entrainment seemed to rise and fall not depending on the topic but rather depending on other factors such as how quickly the problem was solved, who was speaking, or the point of time in the class period.

The balancing equations rituals seemed to encourage students to acquire collective symbols, develop feelings of group membership associated with the class, and transfer these feelings of membership to engagement with the topic over time. It is possible that science terms, symbols such as the form of an equation \(2H_2+O_2=>2H_2O\), and problem-solving procedures became charged with EE. It is also possible that the practice of balancing equations itself was the focus, rather than the associated symbols. Another possibility is that the talk surrounding the problem solving served to unite the group, functioning as a kind of ‘‘shop talk’’ (Collins, 2004). Through continued interactions, the students may develop better means of communicating their approaches to solving chemistry problems, which could serve as a basis for group membership.

Why was the ‘‘balancing equations ritual’’ seemingly more effective at increasing voluntary participation, support for others’ learning, greater respect for peers’ contributions, and interest in the topic, when compared with rituals such as the McNabb problem? One difference between the balancing equations ritual and the McNabb ritual is the timing of when in the interactional event the science language and procedures were introduced. For balancing equations, the focus of the ritual was on the science itself, rather than another membership group, providing a distraction or a break from the science, as in the case of the McNabb vignette.

Based on student comments and classroom observations it seems that Linda’s response to being out of her field was a particularly salient factor. Despite the hesitation in Linda’s chemistry
lectures and students’ occasional confusion, many students enjoyed and participated more frequently in the chemistry unit than in the physics unit (Loman, 2005). Angela described:

> Chemistry was more fun. I don’t really know why. Maybe . . . I think I am better at it. I also felt we were all learning it at the same time, rather than some people knowing a lot more than others.

Angela’s perception was that there was less distance between the students in terms of their knowledge. Her perception may have been influenced by the greater number of opportunities for student participation in providing explanations in chemistry. Linda described how, when teaching chemistry, she developed the habit of giving students more opportunities to respond to each other rather than giving the answer herself. One of the student researchers, Lisa, examined instances where Linda did not know the answer to students’ questions. She was not able to find any examples during the physics unit, but found many examples in chemistry. She stated, “Usually Ms. Loman will ask another student to answer or will go ask Ms. Martin or Ms. Olitsky.” The students became somewhat accustomed to taking a more active role in the chemistry classes, asking questions, volunteering answers, and practicing using the science discourse (Loman, 2005). Rather than losing respect for Linda, students seemed to respond in a positive way to Linda admitting when she did not know an answer or understand why something had gone wrong. Following are some student comments:

> Ashley: Teachers should know the answer, but when they don’t it does get more students to pay attention.
> Aileen: We kind of like it when teachers make a mistake. Then I don’t have to feel so stupid if I don’t know something.
> Monique: We could see that Ms. Loman had to learn stuff too, she did not know everything. Sometimes you are good at one thing and bad at another, well not bad but you have to learn it. So I felt less stupid asking my friends questions so I could better understand.

Other students described how during chemistry they often felt that they could participate without risking negative comments from other students, particularly when they saw that Linda
was willing to admit when she was still struggling with the material. Although the students still recognized that Linda’s knowledge of chemistry was much stronger than theirs, these and numerous other student comments suggest that students were not as afraid of Linda being judgmental of their wrong answers, that they felt more comfortable with themselves not knowing everything, and that they felt it was more acceptable to turn to peers for help. Counts conducted using the videotapes indicate that students were much less negative toward each other’s ideas in chemistry and that a greater variety of students volunteered answers to questions in chemistry (Loman, 2005). These experiences may have boosted EE levels and made the classroom environment more conducive to successful IRs and supportive behaviors surrounding the use of science language.

A related issue is that the balancing equations ritual may have stimulated group membership and interest associated with science because the students’ science contributions were valued. Rather than providing comments that were marginally related to science, such as those about Tampa Bay football players, or one-word answers in IRE dialogue to a teacher who already knew the answers, in the balancing equations rituals the students were able to make contributions that were helpful to their peers in solving the problem. Even the students who were not directly influencing events at the board still offered ideas and added to the building of a common rhythm among the students and teacher. The class seemed to pursue the collective goal of having all students understand the problem, rather than what sometimes had occurred, with a few students gaining status by demonstrating their knowledge to the teacher and other students gaining status by criticizing their peers for incorrect responses. Students’ comments during the problem, closer to the “legitimate peripheral participation” that Lave and Wenger (1991) described, contributed to successful IRs and a classroom that more closely resembled a
community of practice surrounding science. This is not to say that teachers should not reference membership groups other than science, as such references can help to build valuable social ties between the teacher and students. However, such references may not be sufficient for encouraging a science type of membership.

In this eighth grade class, the students had not yet learned to balance equations, and math was associated with low levels of EE for some of the students. Yet the positive attitude of the students in this class toward the seemingly irrelevant and difficult activity of balancing equations suggests that perhaps successful interaction rituals can facilitate student engagement even with content and procedures that are new, abstract, and are not yet associated with EE. The success of balancing equations in this class provides evidence in support of Collins’s (2004) idea that “the content of talk is chosen for the sake of the rhythms of interaction.”

Conclusions

Teachers face challenges in encouraging mutual focus, entrainment, and solidarity in science, particularly given issues such as large classrooms, constraints in what they can teach because of extensive testing, images of science as overly distant and objective that serve to exclude rather than encourage group membership (Barton & Yang, 2000; Lemke, 1990), and the lack of relevance of the material to many students (e.g., Elmesky, 2001; Seiler, 2002). A practical question for teachers is not only how to avoid, for example, discouraging images of science, but also what can be changed in classrooms to make the environments more conducive for solidarity-building interactions that can instill students with a sense of group membership and promote sustained interest. Although often teachers are expected to focus on content-related
goals based on state or district standards, goals involving students’ sense of belonging are also crucial, because if students do not feel a sense of membership associated with science, science will not become part of their identities and they will be unlikely to seek out interactions involving science in the future (Brickhouse, Lowery, & Schultz, 2000). Avoiding such interactions will negatively affect their achievement and reduce the likelihood they will seek out professions and/or interests that involve science, which can limit their life choices and potentially contribute to social reproduction (e.g., Elmesky, 2001).

This in-depth case study of the classroom characteristics and teaching practices that contributed to successful IRs, group membership, and longer-lasting attachments to science discourse and procedures in an eighth grade urban classroom has implications that could be helpful for teacher educators and for teachers working toward community-of-practice–type environments in their own classrooms. It also shows that successful IRs can contribute to student interest even in topics that had previously been considered not relevant to students’ everyday lives, implying the strong role that positive science classroom experiences can play in not only developing students’ prior interests but also in helping them to acquire new ones.

The three IRs discussed herein had some similarities in that they all involved an object of mutual focus, some side-talk, a participatory role for students, opportunities for entrainment, and the building of solidarity between participants. In the first example of a lab activity, the student was able to participate in a successful IR that entailed a science-related mutual focus, exchange of capital with the teacher, and opportunities to provide scaffolding for others within a community surrounding science. However, because of time constraints, the teacher was unable to visit every group, so while some students were affected by similar interactions, others were left
out. This limitation of individualized teacher–student interaction highlights the need for focusing on how whole-class interactions can also lead to successful IRs.

In the second example of an IR during whole-class interaction, local sports figures served as an effective mutual focus, yet entrainment was reduced when the teacher began discussing the math. In the third example of balancing equations in whole-class activity, the chemistry problems themselves became invested with EE, which seemed to contribute to longer-lasting interest in the subject and students supporting each other’s learning. Issues that related to these differences in outcomes between the two whole-class IRs included whether the mutual focus for the IR was centered on science, the level of challenge of the problems, the role of the teacher, the types of participation solicited from students, whether there were viable roles for students within collective, science-related activity, and the level of risk for students participating, as the students were more tolerant of each other’s mistakes when the teacher was out of field. The present results have implications for other teachers who would like to facilitate successful IRs within their own classrooms. Rather than focusing primarily on issues of content or on the quantity of student participation, teachers may benefit from considering how various instructional approaches and classroom conditions influence whether the interactions surrounding science allow for emotional and physical entrainment and are experienced by students as successful. Questions that teachers can ask themselves as they plan activities include: Which symbols and ideas serve as a mutual focus? Is there sufficient challenge, time, and opportunity for entrainment to develop? Does the division of labor between teacher and students allow for peripheral participation of all students? Do students’ contributions in this activity involve science discourse and procedures and are they considered substantial by their peers? If teachers can facilitate successful IRs that lead to students associating science-related symbols and procedures with EE,
these teachers may be more successful in promoting learning environments characterized by student support for their peers’ learning and sustained interest in science.

The results also suggest some questions and paths for future research into the development of students’ sense of group membership surrounding science. For example, this study suggests that curricular relevance is neither necessary nor sufficient for helping students engage themselves as active, valued participants in a community surrounding science and for fostering interest in the subject. However, it would be helpful to investigate the applicability of this finding to other types of schools, contexts, grade levels, and curricula. In addition, the present findings suggest that the common teacher strategy of directing easy questions at students who may have difficulty with science may not be as effective at facilitating a sense of accomplishment and belonging as some would expect, partially because students ascribe different levels of status to their peers depending on the type of contribution. Future research might examine how the contributions that students consider high status vary between educational contexts and how the different approaches that teachers use in order to solicit class participation relate to the development of physical and emotional entrainment among students.

Research that is specific to particular activity structures would also be beneficial, such as studying the conditions that influence entrainment, solidarity, and group membership during laboratory activities. In the examination of IRs during lab work in this particular study, questions remained regarding how to foster solidarity-building, science-centered interactions in labs when students may have less access to science-related cultural capital because the teacher does not have the time to work with all of the groups. Other questions include the relationship of lab participation to the sense of group membership in the classroom as a whole and the sustainability
of interest in science language and procedures beyond the duration of any solidarity-building lab interactions that occur.

Studies could also focus on the effect on classrooms when teachers intentionally strive to establish conditions and implement practices that facilitate IRs. In this particular study, the teacher was not designing her instruction based on this goal, yet a comparison of unsuccessful and successful IRs that emerged in her classroom throughout the school year allowed for the analysis of the relationship between IRs, group membership, interest in science, teacher practices, and classroom conditions. Action-based research in classrooms in which teachers are working toward change by specifically focusing on the generation of IRs surrounding science would be helpful in further developing and refining the hypotheses explored in this investigation.

Some teachers may assume that it is difficult to foster a sense of group membership surrounding science, as the social ties between youth are often focused on aspects of youth culture such as sports, fashion, and music rather than on their academic subjects. Science in particular may be seen as a distant group from the students (Barton & Yang, 2000; Lemke, 1990) and therefore not a viable membership group for students to join. However, this study shows that science-related activities, even if students do not find the content relevant, can also serve as an effective mutual focus for successful IRs. In particularly successful interactions, not only do symbols from the past circulate, but also new ones are generated, including those involving science. In some ways, the generation, acquisition, and use of symbols can be understood as a form of learning. Each new group that a person joins requires learning the proper use of the symbols, such as how to discuss the plays of a football game; the relevant merits of different singers; and, in two of the successful IRs described, the use of science discourse and procedures within collective activity.
References


