Article

SAGE Open
July-September 2014: 1–10
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DOI: 10.1177/2158244014550619
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Exploring Social Dynamics in School Science Context: An Ethnographic Case Study

Mehmet C. Ayar[1], Wenda K. Bauchspies[2], and Bugrahan Yalvac[3]

Abstract

The purpose of this study was to explore the socio-cultural practices and interactions of learning science in a science classroom within the concept of communities of practice. Our qualitative data were collected through observing, taking field notes, and conducting interviews in a public science classroom during an entire school year. The study occurred in a seventh-grade classroom with a veteran physical science teacher, with more than 10 years teaching experience, and 22 students. For this article, we presented two classroom vignettes that reflect a sample of the participation, practice, and community that was observed in the science classroom on a daily basis. The first vignette illustrated a typical formula of Initiation–Response–Feedback (I-R-F) that transfers knowledge to students through a teacher-led discussion with the entire class. The second vignette described a laboratory activity designed to allow students to apply or discover knowledge through practical experience, while taking responsibility for their learning through small-group work. The normative practices and routine behaviors of the science classroom are highlighted through the description of material resources, and different modes of participation accompanied by assigned roles and responsibilities. What we observed was that laboratory activities reproduced the epistemic authority of the I-R-F rather than creating collective cognitive responsibility where students have the independence to explore and create authentic science experiences.

Keywords

communities of practice, school science, learning environment, participant structures, power relationships

Introduction

We begin with the contextual practices that communities perform to define the types of learning and knowing to study the practices that engage individuals with the social world to develop, share, and maintain knowledge evolve over time (Collins, 2006; Enyedy & Goldberg, 2004). For example, in professional science communities, scientists perform their contextual practices to generate new knowledge, and scientists-in-the-making develop ideas, goals, and plans to continue to do scientific practice. On the contrary, in most schools, science classroom communities' practices are viewed as the safe version of scientists' practices performed in their communities (Archer et al., 2010). In addition, we recognize that there are classroom science practices unrelated to practices of scientists in research laboratories (Chinn & Malhotra, 2002; Hofstein & Lunetta, 2004), such as curriculum objectives, standards, and standardized testing. These practices may discourage students to learn from authentic tasks relevant to real-world problems (Höngström, Ottander, & Benckert, 2010) and do not reflect the social nature of practice that encompasses commitment, uncertainty, peer review, and so on (Bricker & Bell, 2008).

Thus, our premise is that the practices of science and the practices of the science classroom are divergent with dissimilar social contexts. To understand these science classroom practices, we asked the following research questions to explore the socio-cultural practices and interactions of learning science in a science classroom to identify the normative school science practices, interactional patterns, and power relations:

Research Question 1: What are the students' science practices?
Research Question 2: What is the nature of the "participant structures" that emerged within the scientific events the students performed?

[1]The Scientific and Technological Research Council of Turkey (TUBITAK), Ankara, Turkey
[2]Georgia Institute of Technology, Atlanta, USA
[3]Texas A&M University, College Station, USA

Corresponding Author:
Mehmet C. Ayar, The Scientific and Technological Research Council of Turkey (TUBITAK), Akay cad. No: 6, Bakanliklar, Ankara 06420, Turkey.
Email: ayar.mehmet@tubitak.gov.tr

Research Question 3: What dimensions of the communities of practice emerge within these events?

The article begins with a discussion of the meaning of communities of practice in relation to the social structure of a typical science classroom. We address these communities of practice to focus on the group behaviors versus individuals. After a discussion of the methodology, we present and analyze two vignettes that illustrate observed classroom members' engagement and interaction in two different contexts: lecture and laboratory. The discussion of our findings outlines the social dynamics that trigger and hinder the formation of a classroom community of practice within a science classroom. Our findings are important for designing learning environments aimed to cultivate science learning through participation, belonging, and practice, in ways that might mimic professional scientific communities of practice or foster learning through discovery.

Theoretical Framework

School Science Classroom and Its Social Structure

Our study will use a socio-cultural approach to provide an understanding of the social and cultural systems of classrooms and students' classroom involvement (Kozulin, Gindis, Ageyev, & Miller, 2003). Within a classroom culture, members construct social norms and rules as they develop different roles and establish relationships among themselves and participant identities (Collins, 2006). The social authority and epistemic role of the teacher contribute to the configuration of the classroom culture by organizing and managing normative classroom practices, and in establishing interactions (Bauchspies, 2005).

Conflicts, tensions, and disagreements are central to form and sustain a classroom community of practice and are central to this study for understanding the emergence or absence of a community of practice within a science classroom (Wenger, 1998). Individuals develop common knowledge through sharing and negotiating their understanding and experience with each other in most classrooms (Elbers & Streefland, 2000). They may encounter conflicts with other students or resistance to their ideas, thoughts, and claims when engaged in activities with a discussion component (Olitsky, Flohr, Gardner, & Billups, 2010; Oliveira & Sadler, 2008). When this occurs, these temporally emergent circumstances are accommodated through the social interactions and negotiations among the classroom members (Mortimer & Scott, 2003). This study will focus on these temporal emergent circumstances because they lead to a shared repertoire among the members and help develop individual roles and identities (Olitsky et al., 2010).

Philips (1972) coined the term "participant structures" as the context of participants' engagement, their social norms, relationships, roles, and responsibilities, and the materials and knowledge acquisition. We analyze and articulate the social structure of a science classroom using "participant structures" to explain (a) how class members participate in and sustain their practices, (b) what roles the teacher and the students are engaged in, (c) what relationships they establish in maintaining memberships, and (d) what types of resources are shared and generated (Cornelius & Herrenkohl, 2004; Tabak & Baumgartner, 2004).

A community of practice encompasses three indicators—mutual engagement, joint enterprise, and shared repertoire (Wenger, 1998). Mutual engagement is attributed to membership, diversity, and relationship within a community that creates a joint enterprise among the members:

> The enterprise is the result of a collective process of negotiation that reflects the complexity of mutual engagement. It is not just a stated goal, but creates among participants relations of mutual accountability that become an integral part of the practice. (Wenger, 1998, pp. 77-78)

This in turn creates a shared repertoire as a set of resources, including routines, ways of doing things, words, tools, actions, concepts, or discourse that the community members use and/or produce to sustain their memberships in a community.

Central to a community of practice are participation and identity transformation (Wenger, 1998). Participation is a catalyst to developing and sustaining a community of practice in a way that shapes members' actions and identities. Participation is not limited to engaging in activities; it is also a process of becoming a full participant. In this sense, Roth (1998) suggested that students be encouraged to engage in authentic tasks in a community of classroom practice in which a novice learner or a newcomer adopts and uses a classroom community's norms and beliefs to become a full member of that community as opposed to grades and exams emphasized in most conventional classrooms (Barab & Duffy, 2000). Identity transformation occurs in the context of becoming a full member in a community. Individuals at different levels of participation and membership become familiar with and use knowledge, and master skills of a community through their personal trajectories of participation (Clark, 2005). In the classroom context, a student learns as she develops and transforms her identity through her personal trajectories of participation in a shared school science practice.

Researchers have been interested in developing a community of practice in educational settings (Aguilar, 2009; Clark, 2005). They examine the elements of communities of practice and use communities of practice as a framework to understand how individuals learn. Yet, there are a few studies that explore and document the potential dynamics that determine whether or not a community of practice emerges within school settings, and how it does or does not emerge (Aguilar, 2009; Olitsky, 2007; Roth, McGinn, Woszczyna, & Boutonne, 1999).

Aguilar (2009) has identified students' learning in school science context by addressing the three interrelated constructs: (a) mutual engagement, (b) joint enterprise, and (c) shared repertoire. In her model, knowledge transmission by the teacher and non-participations of the students was a barrier to the development of a classroom community of practice. Whereas Olitsky (2007) observed that different types of interactional events (e.g., one-on-one and whole-class) are a means to increase student engagement and student learning as well as to form a classroom community of practice, Roth et al. (1999), in contrast, found that a small number of students participated in science classroom discourse practices, although students were provided with the opportunity to develop their own artifacts through different levels of social configuration (e.g., whole class and small group).

In this study, we contribute to this line of inquiry with a study of learning and teaching science in a seventh-grade science classroom by highlighting the normative school science practices, interactional patterns among members of the classroom, power relations, and cultural portrait of the classroom. To address these issues, we examine the elements of the classroom's community of practice.

Method

The Setting

This ethnographic study was conducted in a public school classroom in North America. With one class for each grade level, the school hosted approximately 250 students in kindergarten through 12th grade in the same building. The school served a middle-class neighborhood in mid-sized community located nearby a major university. Several schools in the targeted community were approached and this one self-selected itself to be the focus of this study. The 7th-grade classroom, which is the focus of this study, had 22 students at the ages of 13 and 14. Of the 22 students (7 males and 15 females), around 18% were African American, 36% were Hispanic American, and 46% were European American. Its racial breakdown was representative of the community.

Ms. Corbin[1] was the certified physical science teacher. She has been teaching seventh- and eighth-grade science courses in the middle school and physics, biology, and chemistry courses in the high school over 10 years. For the last 3 years, Ms. Corbin has been organizing and supervising in- and out-school activities relevant to physical sciences. During the year of observation, she used the science curriculum that conformed to the state's science standards.

Data Collection and Analysis

This study was conducted in one science classroom to develop a "thick" description of the community of practice within it. Specifically, our aim was to determine the social dynamics that support or hinder the emergence of a community of practice in the school science context via normative school science practices, interactional patterns, and power relations.

Participant observation method was employed to thoroughly explore students' behaviors and actions during the classroom cultural activities (Spradley, 1980). The first author closely engaged with the teacher and the students in the classroom for an academic year. During laboratory activities, the investigator interacted with students in groups and one-on-one and sometimes participated in labs as a member of the team. During these interactions, the investigator asked the students both rhetorical and literal questions to document what they thought they were doing in the laboratory activity.

The observer's role in class changed over time from a passive participant role to an intermediate participant role. He maintained the balance "between being an insider and an outsider, between participation and observation" (Spradley, 1980, p. 60) by gradually adjusting his participation in the activities and timing his questions to the activity. This strategy allowed him to capture the local occurrences in the classroom. As a participant observer, the investigator supervised the students' extracurricular science fair projects at the request of students and the teacher. In his role as the science fair supervisor, he offered support to students' projects but abstained from directing their projects.

Observation notes were made during visits and daily journal entries provided additional details. The field notes and daily journal included classroom observations and the observer's self-reflections about the events of the classroom. They also included notes on conversations with the students and Ms. Corbin in and outside of formal classroom activities. Formal interviews were recorded and transcribed.

Two data analysis methods were employed: (a) the ethnographic data analysis method (Spradley, 1980) and (b) the constant-comparative method (Glaser & Strauss, 1967) to analyze data collected through participant observation and interviews, respectively. Interviews were transcribed verbatim. Interview transcripts and participant observations were merged with the daily journals and artifacts (e.g., handouts, student presentations, and quiz or test sheets) to identify normative school science practices, interactional patterns, and power relations.

Vignette 1: Presenting, receiving, and reproducing ready-made scientific facts

The focus of the lesson is a quiz about deoxyribo nucleic acid (DNA) base pairing. Before the quiz, Ms. Corbin has students recall DNA structure, and in their words, it is a "twisted ladder," while the teacher uses its technical term "double helix." Ms. Corbin distributes quiz sheets. Each sheet has different samples of DNA structure. Meanwhile, she instructs her students that they can gain extra credit if they write the names of four bases correctly. Tim responds to her by asking, “What if I misspell the names of the bases” because “the names of bases are not so familiar to me, and they sound like technical terms.” Ms. Corbin answers him by speaking to the entire class, “Unless there are major misspellings, you will get credit.” At this point, she gives students 3 min to complete their quiz.

When students finish the quiz, Ms. Corbin picks a DNA sequence sample from the quiz and writes it on the whiteboard. She asks students, “What does Adenine (A) pair up with?” One student responds, “A pairs up with Thymine (T).” Ms. Corbin continues to ask, “What does Cytosine (C) pair up with?” Another student tells, “Guanine (G),” and so on. When Ms. Corbin and students have finished to pair up the four bases (A, T, G, S), she lists and writes down the names of four bases on the whiteboard. At the same time, students self-check whether the names of four bases are written correctly on their quiz sheet. Yet, the teacher does not grade students’ quiz nor are they recorded in her gradebook. After students put the quiz away, Ms. Corbin moves on to the next activity.

Ms. Corbin asks the students, “How does DNA determine your traits?” She writes DNA and ribonucleic acid (RNA) on the whiteboard. She asks first, “What does DNA stand for?” Tom says, “Deoxyribonucleic acid.” Then Ms. Corbin explains that the only difference between DNA and RNA is deoxy, which RNA does not have. Therefore, RNA stands for ribonucleic acid. She jots down the full names of DNA and RNA on the whiteboard. She asks the students to recall the four bases in DNA. They express and list four bases—A, T, C, and G. She immediately interjects, “RNA does not have T base; instead, it has Uracil (U) along with other three bases.”

By using recall and reminding techniques, Ms. Corbin describes DNA, mRNA, and tRNA, and notes their traits on the whiteboard. Meanwhile, the students are busy with writing notes about RNA and its four bases in their notebooks. Then, she asks them to get a clean sheet of paper and instructs them to “Flip your paper in half vertically and then flip the other half in half again. You will have four columns.” Meanwhile, she walks around and surveys whether students have it as she has instructed. She is back to the whiteboard and writes a sample of DNA sequence—CATGCTAAT—on the whiteboard. She instructs the students to label four columns with headings: mRNA, tRNA, protein, and traits. She has them note that mRNA is a messenger RNA; tRNA is transfer RNA.

Ms. Corbin explains, “C in DNA sequence pairs up with G in mRNA.” She asks Danielle, “A in DNA pairs up with what?” to which Danielle hesitantly says, “U?” Meanwhile, other classroom members are insistently holding their hands up to get permission to answer this question. Ms. Corbin reminds everyone, “RNA does not have T base; instead it has Uracil.” She marks it with a star on the whiteboard. She continues by questioning the class with “T in DNA sequence pairs up with what?” She goes through a sample of DNA sequence by pairing up the bases in mRNA and tRNA. Every time, she points to the U base in the RNA sequence.

When the students finish pairing up bases, Ms. Corbin asks them to look up the information provided in their activity sheet to identify protein codes based upon triple bases in the mRNA sequence. When there is no response from them, Ms. Corbin adds, “GUA sequence is called Valine according to the information in the activity sheet” and “CGU sequence is Arginine and UUA sequence is Leucine.” She finishes with “these are the types of amino acids.” Ms. Corbin encourages students to imagine the whole sequence of DNA and its counterparts in mRNA and tRNA sequences by what kinds of amino acid are produced. When students do not answer, she answers for them with, “If we consider the whole sequence of amino acid, then it looks like hitchhiker’s thumb.”

Vignette 2: Learning by doing some practical works

On one Monday afternoon, Ms. Corbin starts the class by telling students, “We will have a lab activity about the physical and chemical changes.” A whisper of “YES” is heard softly echoing among the students. Before the lab activity starts, Ms. Corbin calls out the names of each lab group. Recently, she reconfigured them based on academic performance, behaviors, and gender. Each group has a designated leader assigned by the teacher and is typically the student with a strong academic performance. The group recorder is selected by the group leader.

Students rearrange themselves into their laboratory groups. Ms. Corbin distributes laboratory sheets to six groups of four students. She reads the first page of the laboratory sheet where lab purpose, procedures, and materials are listed. While Ms. Corbin reads the procedure section, she points to the materials and equipment that the students will be using. Then, she assigns one student in the classroom to read out loud for the class the rest of the laboratory sheet.

While students hold up their hands to volunteer to read it, she selects Beril who does not have her hands up and is quietly reading a novel. Beril reads the entire lab instruction step by step. When she finishes reading it, Ms. Corbin instructs one student from each group to collect goggles and gloves, while another student gets test tubes, chemical substances, spatula, and pestle. Students assigned to obtain the experiment materials move next to the bench where Ms. Corbin has located the equipment and the substances. At the bench, they talk to each other about which equipment they will need, how many test tubes they will use, and which substances they will first use.

Today’s laboratory activity is composed of five mini investigations about physical and chemical changes. In one group, Julie as the designated group leader asks who will do which investigation. At that moment, each member looks at the possibilities and self-selects an assignment. Julie dominates the group and assigns herself as a recorder even though

Terri self-selects herself to be a recorder. Terri and other students in the group wordlessly acquiesce to Julie. As the leader Julie asks the group members' thoughts and ideas before she writes the group's findings. She puts forward her thoughts and ideas when other students do not share their ideas and thoughts; the other members simply agree with no discussion. At the end of the laboratory sheet, Julie again provides the answers for the group to write them down. The group agrees with her and accepts Julie's final statements without discussing their observations or conclusion from each investigation.

While each group is busy conducting the experiments and identifying the physical and chemical changes, Ms. Corbin stops by each group, checks what group members are doing, and asks them, "What stage are you at?" She continues to monitor the groups, while some group members ask for help to answer a question about the procedures and their investigations. She provides guidance. As necessary, she answers the questions directly. At other times, she responds with a question to allow them think and discuss in groups.

When Ms. Corbin realizes that students completed the activities on the first page of the laboratory sheet, she asks them to continue on the second page where they will record their observations in a chart and explain whether the changes in matters are physical or chemical. Each group finishes experimenting, recording observations, identifying physical and chemical changes, and answering questions on the laboratory sheet. Ms. Corbin asks the groups to discuss similarities and differences between the physical and chemical changes in another worksheet. She picks Kevin to give an example, and Kevin suggests that eroding is a physical change. Another student, Rena, disagrees with Kevin's example because she thinks that it is a chemical change. At that moment, some students agree with Rena and some do not. Ms. Corbin encourages the students to provide evidence and to explain why it is physical change or not. Disagreement on that example lasts a while and then is resolved by Ms. Corbin. She concludes, "I think that eroding is an example for both physical and chemical changes." Ms. Corbin and her students continue discussing other examples regarding chemical and physical changes until the bell rings.

Findings

Student Science Practices

In the seventh-grade science classroom, Ms. Corbin's normative practices were to set the agenda and orchestrate both regular classroom and laboratory activities. As a knowledge transmitter and a source of knowledge, she used the power of knowing and the authority to determine, plan, organize, and implement the everyday activities of the classroom. In the interviews, several students described the teacher's role as the director and knower:

> Ms. Corbin determined what activities we would do and why we will do those. She determined them because almost everyone in the class can participate in them and understand what's going on. (Student 2)

> She [The teacher] hands us worksheets. And we know she has more knowledge and experience than us. (Student 1)

Ms. Corbin used a computer and a projector in the classroom that gave her access to for Microsoft office program applications (e.g., word processing and Power Points) and the Internet. She used these technologies to present knowledge and to implement instructional activities. For example, the teacher used the projector to exhibit the picture of chromosomes to enable students to imagine and conceptualize how and under what conditions people are born with Down's syndrome. The projector was a tool for her to draw students' attention to the topic and concentrate on the picture displayed. The computer and its accessories are technologies of direction used by the teacher to monitor student's readiness to quizzes and exams as well as to disseminate ideas, concepts, and terms easily.

In other lessons, the computer and projector were used by students to share their projects with the classroom. Students had projects to present over two semesters. Although some groups preferred making a poster, some groups prepared PowerPoint presentations with animations and visual effects to draw their peer's attention. Again the computer and projector are being used as a technology of direction, this time by the students within the classroom. The technologies were used in similar ways by the classroom community to facilitate teaching and repetition of scientific concepts as a recognized social practice of the classroom.

In addition, Ms. Corbin prepared handouts and used them to guide and support student learning. Handouts in-class activities included worksheets, quiz sheets, and course notes. These handouts pertained to knowledge presented in their science textbook. These paper technologies reinforced the teacher's role of director and knower and rarely shifted those roles to the students. One student summarized this in her interview:

> In our class we usually get worksheets or lab experiments or something like that or either our teacher or book would provide the correct answer or a correct possibility or any possibilities, but in unknown answer—I wouldn't really expect that . . .

As illustrated in the second vignette, students were provided with laboratory handouts. These handouts listed the purpose, the procedures, and the materials. The students were also provided with laboratory materials and equipment (e.g., microscope, pH meters, gas pressure sensors, and balance) to conduct their scientific investigations and complete their lab assignments. These material resources were the shared repertoire in the classroom community where the students performed both in-class and lab activities to learn scientific concepts. They too reinforced the role of students as actors who follow the guidance of the director or teacher. Ms. Corbin preferred using the Initiation–Response–Evaluation (I-R-E) and Initiation–Response–Feedback (I-R-F) interactional sequences. That is, she preferred initiating a question about a term, students responded to that question, and then she evaluated their response or provided feedback (Mortimer & Scott, 2003). She used these question–answer routines between her and students to coordinate the regular classroom activities as exemplified in the first vignette. For students, however, they responded to the I-R-E or I-R-F strategy as another version of listen, receive knowledge, and take notes.

In the second vignette, students are observed being more actively engaged with knowledge production through laboratory activities to recall and verify knowledge. Students are also asked to apply that knowledge and develop inquiry skills to complete the laboratory activity. Typically, the lab activities were simple hands-on activities that the students completed by following the prescribed procedures (Chinn & Malhotra, 2002). Meanwhile, Ms. Corbin maintained her role as a director by provided feedback, monitored their performance, and mentored them (Tabak & Baumgartner, 2004).

In this classroom, the students were expected to work in assigned groups and to accomplish their task in a collective manner. Some students dominated the group's work to accomplish their normative laboratory practices. Other students took the responsibilities designated by their group leader mostly and rarely by their self-choice. As part of her normative practices, Ms. Corbin intended to form diverse student groups in regard to sex, behavior, and academic performance every several weeks. She organized pair and small groups to regulate the laboratory activities where students were expected to work in groups. Ms. Corbin always monitored the students' group work as to whether they were working together or not. She encouraged them to work together for the completion of the activities. Working together was a tacit and invisible norm during the laboratory activities that was constantly reinforced by the teacher's verbal and nonverbal clues.

Different students responded differently to the assigned groups because of pre-existing relationships within the classroom from several years of going to school together. One student explained the group's dynamics from a historical perspective:

> . . . We're a pretty hardworking class, although we know how to get on—on the teacher's bad sides. We've been doing that for years though so—but you know, we can work well if uh . . . hmm, we're in the right groups. We all know each other pretty well because we've been in this school for more than one year in most cases. (Student 2)

Another student characterized the dynamics from a social grouping perspective:

> The ways the groups are made usually depend. If I were in a group with not my friends, then we probably would have been assigning stuff that each person brings, but when I'm with my friends, we kind of just take the responsibility ourselves without assigning it. (Student 5)

By focusing on the normative practices and routine behaviors of the classroom, we see that community of practice is centered on the teacher as a director. Whereas students' community of practice either follows the direction of the teacher or illustrates autonomy when assigned groups overlap with social groupings that exist outside of the classroom.

The Nature of the "Participant Structures" in the Science Classroom

Ms. Corbin established different modes of participation to support students' participation in their everyday activities: (a) individual mode, (b) pair mode, (c) small-group mode, and (d) whole-class mode.

By individual mode of participation, we refer to the interactions between a student and a teacher (Philips, 1972). In this type of participation, all students worked individually under Ms. Corbin's guidance on an assignment. Ms. Corbin acted as an authority figure, and checked and controlled the students' behaviors and attitudes to teach scientific topics. Students were encouraged to ask questions if anything was not clear to them. When the students had questions, they called on Ms. Corbin as the expert or authority who was responsible to respond to their inquiries. This individual mode of participation defined the students as receiving objects (Freire, 2000).

Pair mode of participation can be attributed to the interactions between two students under Ms. Corbin's guidance. Students in pairs shared their understanding, experience, knowledge, competence, and responsibilities. In the meantime, Ms. Corbin was in the role of facilitating. When a pair group had a conflict or a disagreement, Ms. Corbin helped them out through feedback. The pair mode of participation occurred as students were engaged with both the regular classroom and laboratory activities. For example, when designing a solar oven model as a project work, Ms. Corbin set pairs who would decide their own best model to cook something. The students were encouraged to negotiate how to design a model, what kind of materials they would use, and how to use the model to conduct their investigations. While the students were the center of action and discussed each step to design the model by sharing their ideas, Ms. Corbin monitored each group, provided feedback, and checked their performance. Students in pairs acted in a collaborative manner as they mutually communicated their ideas with each other and shared with each other their knowledge and the experience that helped them accomplish their assignment. In addition, they were in symmetric interactions where no one dominated their conversation, which in turn developed the sense of ownership of the model they designed (Oliveira, Sadler, & Suslak, 2007; Tabak & Baumgartner, 2004). This pair mode of participation defined the students as acting, collaborating, and sharing individuals.

Small-group mode of participation is one in which students work in a small group with more distant teacher supervision (Philips, 1972). In this type of participation, Ms. Corbin was in the role of mentoring each group and supporting their articulation of ideas among the students in each group (Tabak & Baumgartner, 2004). Ms. Corbin frequently initiated the small-group mode of participation when the students frequently performed laboratory activities as illustrated in the second vignette. Given that the students were the center of action, they were responsible for doing their own investigations. To accomplish their lab assignment, they were provided with the opportunity to determine the division of labor in each group. Although they were not urged to be in the pursuit of the unknown, they worked and completed lab assignment collectively, and negotiated their conflicts and disagreements with regard to investigations, observations, and findings. In turn, their mutual negotiations led to transforming their disagreements into agreements. This small-group mode of participation defined the students as more acting, engaging, collaborating, and sharing individuals.

Whole-class mode of participation can be attributed to the teacher-initiated whole-class interaction where the teacher dominates her social and epistemic authority to orchestrate the classroom practices and maintain continuous science learning (Turpen & Finkelstein, 2010). In the whole-class mode of participation, Ms. Corbin was the center of action; therefore, she established asymmetric interactions with the students. She was in the role of leading conversations, transmitting knowledge to the students, and motivating the marginal students to engage in discussions through asking rhetorical and literal questions. In the meantime, many students voluntarily participated, listened to her, and rarely raised questions as shown in the first vignette. Ms. Corbin preferred to employ the I-R-F sequence to manage the whole-class interactions. The I-R-F sequence motivated students to participate in a conversation and discuss scientific concepts. Yet, the I-R-E sequence existed when students were engaged with question–answer routine activities. This whole-class mode of participation defined the students as more receiving and less engaging individuals.

Dimensions of Communities of Practice in the Science Classroom

Our study findings reveal practice, participation, and community in the science classroom, as dimensions of communities of practice. Practices that the students performed in the classroom consisted of regular class and laboratory activities to become familiar with science subject-matter. Rarely, they were provided with open-ended activities (e.g., designing a solar oven model) to make connections to their daily life.

Participation structures that we observed were organized by the teacher depending on the nature of their normative practices. The individual mode of participation and the whole-class mode of participation were to enhance the individualistic learning through the questions–answer routine works (Lemke, 1990). The individual mode of participation restricted the students to interact and communicate with the other classroom members because they were only in contact with the teacher. The pair mode of participation and the small-group mode of participation provided students with the opportunity to be the center of action, establish different roles, share responsibilities to perform their contextual practices, and develop a collective understanding of a shared practice. In other words, they were given a chance to become more active in a way that encourages them to move from being a peripheral participant to being a full participant (Wenger, 1998). In turn, this can allow identity transformations as their participation level changes and they engage in a shared practice.

We construe community with power relations, authority, and belonging. In this study, the seventh-grade students accepted and internalized that their teacher was the one who plans, organizes, and implements their classroom practices as well as initiates their common goals (e.g., particularly learning and memorizing scientific concepts, having fun, and being successful in science exams) through her power and authority as a component of classroom life (Pace & Hemmings, 2007). Power relations between the teacher and the students were stable. It was already given to the teacher (Bauchspies, 2005; Oliveira, 2010). Students intended to work with their close friends when they were formed in groups because they had common histories and were aware of their good and bad sides. The teacher's epistemic and social authority played a role in configuring various student groups in regard to their academic background, sex, and behaviors. This was discouraging for students to have a feeling of belonging to a group in a specific, and a classroom community in general.

Discussion and Implications

This study has illustrated the normative practices and power relations occurring in two teaching formats for science: I-R-E or I-R-F instructional sequences and small-group laboratory activities share an epistemic authority that limits the participatory potential of both activities.

In the first vignette, the teacher guides and directs student learning as she reinforces and introduces science concepts. She controls learning activities in a directive manner that facilitates one-on-one conversation between student and teacher and rarely between student and student. After the teacher places students into groups, the identified leader acts as a teacher and the group members participate in their normal default role of learners. We see this in the student leader who dominated her group's discussion, assigned roles to her peers, and offered answers to all questions to complete their lab investigations. Thus, the "academic leader of the group" accepts the responsibility and finishes their collective job to maintain her status as leader. Meanwhile, the rest of the group maintain their normal role as learners and do not discuss their observations or results with one another, which reinforces that science discourse is structured by I-R-E or I-R-F sequences. This is supported by studies of what occurs when scientists and students collaborate: The leading scientist typically takes the teacher's role in working with students (Charney et al., 2007).

Laboratory investigations in the classroom are a means for students to conceptualize the subject-matter that is presented during lectures: I-R-E or I-R-F. Lab activities are designed to give students the chance to learn independently or with peers. In the second vignette, we see the students reproducing I-R-F at the end of the lab activity rather than discussing among themselves. The classroom's default mode or established participatory structures shaped the community of practice and limited the development of practices that may have encouraged discussion across groups.

In the second vignette, teacher authority was given to students via their assigned roles and responsibilities. The selection of a student leader based on academic performance gave epistemic authority to only one student, while placing the remaining students in their habitual normative role as learners. The laboratory activity of Vignette 2 gave students responsibility and created a division of labor that mimicked the authority and normative practices of Vignette 1. Whereas the teacher performs her role in an authoritative role, the student leaders perform theirs in an authoritarian manner. This directly challenges the idea that laboratory activities engage students with hands-on learning that enables them to understand and learn science concepts differently from a lecture or class discussion. Our observation and comparison of two typical activities in this science classroom ethnography through the lens of normative practices and participatory modes illustrate the importance of describing the socio-cultural aspects of the school science classroom to understand not only the individual practices of students and teachers but what their communities of practice are creating and reproducing daily.

Conclusion

In this article, we drew on two vignettes to (a) reflect the nature of school science practices, (b) shed light on the interaction and communication structures between students and the teacher, (c) depict how the teacher organizes and manages normative classroom practices for students to understand scientific concepts, and (d) identify the social dynamics that hinder or trigger the formation of a community of practice in the science classroom.

The students were engaged in regular classroom activities (e.g., completing worksheets and assignments through the teacher's knowledge, going over handouts and having mini discussions, and taking quizzes and exams). Research has shown how these "regular classroom activities" produce stable practices that reinforce the goal of higher exam scores (Zakharov, Carnoy, & Loyalka, 2014). During laboratory activities designed to give students intimacy with scientific knowledge, concepts, terms, and natural phenomena, students were observed establishing social relationships patterned using I-R-F that defined their laboratory experiences. Although the teacher provided different participation modes designed to enhance student engagement in activities, social and epistemic authority were not redistributed or altered for activities presumed to develop a norm based on collaboration. The power dynamics that created the student working groups reproduced itself within the groups and affected how students worked together. What we observed was that laboratory activities reproduced the epistemic authority of the I-R-F rather than creating collective cognitive responsibility where students have the independence to explore and to create authentic science experiences.

Thus, barriers and triggers to a community of practice coexist in the science classroom from the teacher's authority to worksheets and laboratory equipment. On one hand, we identified that the teacher's institutionalized role, namely her epistemic and social authority, influenced students' actions, behaviors, and learning activities. At times, this institutional role was a trigger for community of practice in doing worksheets or taking quizzes. However, it was also seen as a barrier to the formation of a community of practice in the laboratory activities. The configuration of working groups based on teacher authority worked as a barrier to developing a collaborative community of practice for students to work collectively as a group. On the other hand, these student groups reinforced the role of the academically strong and weak in their participation in laboratory activity. Students continued to engage, collaborate, and share their ideas and thoughts with others in their established roles within I-R-F. Therefore, this study highlights the importance of the social context and dynamics operating within the science classroom community of practice where practices can trigger or hinder an unintended norm to be reproduced and reinforced, regardless of intended norm.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research and/or authorship of this article.

Note

1. Names of students and the teacher in this manuscript are all pseudonyms.

References

Aguilar, O. M. (2009). *Examining the community of practice framework in environmental and science learning contexts with Hispanic youth* (Unpublished doctoral dissertation). Cornell University, Ithaca, NY.

Archer, L., Dewitt, J., Osborne, J., Dillon, J., Willis, R., & Wong, B. (2010). Doing science versus being a scientist: Examining 10/11-year old school children's constructions of science through the lens of identity. *Science Education*, *94*, 1-23.

Barab, S. A., & Duffy, T. M. (2000). From practice fields to communities of practice. In D. H. Jonassen & S. M. Land (Eds.), *Theoretical foundations of learning environments* (pp. 25-55). Mahwah, NJ: Lawrence Erlbaum.

Bauchspies, W. K. (2005). Sharing shoes and counting years: Mathematics, colonialization, and communication. In A. Chronaki & I. M. Christiansen (Eds.), *Challenging perspectives on mathematics classroom communication* (pp. 237-259). Greenwich, CT: Information Age Publishing.

Bricker, L. A., & Bell, P. (2008). Conceptualizations of argumentation from science studies and the learning sciences and their implications for the practices of science education. *Science Education*, *92*, 473-498.

Charney, J., Hmelo-Silver, C. E., Sofer, W., Neigeborn, L., Coletta, S., & Nemeroff, M. (2007). Cognitive apprenticeship in science through immersion in laboratory practices. *International Journal of Science Education*, *29*, 195-213.

Chinn, C. A., & Malhotra, B. A. (2002). Epistemologically authentic reasoning in schools: A theoretical framework for evaluating inquiry tasks. *Science Education*, *86*, 175-218.

Clark, P. G. (2005). *The emergence of a classroom community of practice in a mathematical structures course* (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3178229)

Collins, A. (2006). Cognitive apprenticeship. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 47-77). New York, NY: Cambridge University Press.

Cornelius, L. L., & Herrenkohl, L. P. (2004). Power in the classroom: How the classroom environment shapes students' relationships with each other and with concepts. *Cognition and Instruction*, *22*, 467-498.

Elbers, E., & Streefland, L. (2000). Collaborative learning and the construction of common knowledge. *European Journal of Psychology of Education*, *15*, 479-490.

Enyedy, N., & Goldberg, J. (2004). Inquiry in interaction: How local adaptations of curricula shape classroom communities. *Journal of Research in Science Teaching*, *41*, 505-535.

Freire, P. (2000). *Pedagogy of the oppressed* (30th anniversary ed.). New York, NY: Continuum Books.

Glaser, B. G., & Strauss, A. M. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Chicago, IL: Aldine.

Hofstein, A., & Lunetta, V. N. (2004). The laboratory in science education: Foundations for the twenty-first century. *Science Education*, *88*, 28-54.

Höngström, P., Ottander, C., & Benckert, S. (2010). Lab work and learning in secondary school chemistry: The importance of teacher and student interaction. *Research in Science Education*, *40*, 505-523.

Kozulin, A., Gindis, B., Ageyev, V. S., & Miller, S. M. (2003). Sociocultural theory and education: Students, teachers, and knowledge. In A. Kozulin, B. A. Gindis, V. S. Ageyev, & S. M. Miller (Eds.), *Vygotsky's educational theory in cultural context* (pp. 1-14). Cambridge, MA: Cambridge University Press.

Lemke, J. J. (1990). *Talking science: Language, learning and values*. Norwood, NJ: Ablex.

Mortimer, E. F., & Scott, P. H. (2003). *Meaning making in secondary science classrooms*. Maidenhead, UK: Open University Press.

Olitsky, S. (2007). Promoting student engagement in science: Interaction rituals and the pursuit of a community of practice. *Journal of Research in Science Teaching*, *44*, 33-56.

Olitsky, S., Flohr, L. L., Gardner, J., & Billups, M. (2010). Coherence, contradiction, and the development of school science identities. *Journal of Research in Science Teaching*, *47*, 1209-1228.

Oliveira, A. W. (2010). Developing elementary teachers' understanding of the discourse structure of inquiry-based science classrooms. *International Journal of Science and Mathematics Education*, *8*, 247-269.

Oliveira, A. W., & Sadler, T. D. (2008). Interactive patterns and conceptual convergence during student collaborations in science. *Journal of Research in Science Teaching*, *45*, 634-658.

Oliveira, A. W., Sadler, T. D., & Suslak, D. F. (2007). The linguistic construction of expert identity in professor-student discussions of science. *Cultural Studies of Science Education*, *2*, 119-150.

Pace, J. L., & Hemmings, A. (2007). Understanding authority in classrooms: A review of theory, ideology, and research. *Review of Educational Research*, *77*, 4-29.

Philips, S. (1972). Participant structures and communicative competence: Warm Springs children in community and classroom. In C. Cazden, V. P. John, & D. Hymes (Eds.), *Functions of language in the classroom* (pp. 370-394). New York, NY: Teachers College Press.

Roth, W.-M. (1998). *Designing communities*. Dordrecht, The Netherlands: Kluwer.

Roth, W.-M., McGinn, M. K., Woszczyna, C., & Boutonne, S. (1999). Differential participation during science conversations: The interaction of focal artifacts, social configurations, and physical arrangements. *Journal of the Learning Sciences*, *8*, 293-347.

Spradley, J. P. (1980). *Participant observation*. New York, NY: Holt, Rinehart, and Winston.

Tabak, I., & Baumgartner, E. (2004). The teacher as partner: Exploring participant structures, symmetry, and identity work in scaffolding. *Cognition and Instruction*, *22*, 393-429.

Turpen, C., & Finkelstein, N. D. (2010). The construction of different classroom norms during peer instruction: Students perceive differences. *Physical Review Special Topics: Physics Education Research*, *6*(2), 1-22.

Wenger, E. (1998). *Communities of practice: Learning, meaning and identity*. New York, NY: Cambridge University Press.

Zakharov, A., Carnoy, M., & Loyalka, P. (2014). Which teaching practices improve student performance on high-stakes exams? *International Journal of Educational Development*, *36*, 13-21.

Author Biographies

Dr. Mehmet C. Ayar is a scientific programs expert in the Scientific and Technological Research Council of Turkey (TUBITAK). He received his Ph.D. in Curriculum and Instruction with specialization in STEM education at Texas A&M University. His research is in ethnographic studies of science and engineering practice, curriculum development, design of learning environments, and robotics activities.

Dr.Wenda K. Bauchspies is an associate professor in the School of History, Technology and Society at Georgia Institute of Technology. She earned her MEd from Towson State University and her PhD in science and technology studies from Rensselaer Polytechnic Institute. She is a sociologist specializing in science, technology, and gender in West Africa from a cultural perspective.

Dr. Bugrahan Yalvac is an associate professor of science and engineering education in the Department of Teaching, Learning, and Culture at Texas A&M University, College Station. He received his Ph.D. in science education at the Pennsylvania State University. Yalvac's research is in STEM education, 21st century skills, and design and evaluation of learning environments informed by the How People Learn framework.