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Chapter 3

A Naturalistic Paradigm: An Introduction to Using Ethnographic Methods for Research in Mathematics Education



Judit N. Moschkovich

Abstract This chapter provides an introduction to integrating a naturalistic paradigm and ethnographic methods into research in mathematics education. The chapter addresses methodological issues specific to designing and conducting research in mathematics education framed by a naturalistic paradigm that includes ethnographic methods and, in particular, using video as an ethnographic research methodology. The theoretical perspective used in this chapter is based on assumptions summarized in a chapter by Moschkovich and Brenner (*Handbook of research design in mathematics and science education*, Lawrence Erlbaum Associates, Mahwah, pp. 457–486, 2000). This chapter focuses on describing and illustrating an ethnographic stance and the design of ecologically valid mathematical tasks, and summarizes design issues for ethnographic research, in particular using video.

Keywords Mathematics education · Methodology · Ethnographic methods · Video

3.1 Introduction

This chapter provides an introduction to integrating a naturalistic paradigm and ethnographic methods into research in mathematics education. The chapter considers methodological issues specific to designing and conducting research in mathematics education that is framed by a naturalistic paradigm and uses ethnographic methods, paying particular attention to using video as an ethnographic research methodology.

Early researchers in mathematics education should be interested in these methodological approaches for several reasons. A naturalist paradigm and

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ethnographic methods expand the set of methodological tools for research on mathematics learning and teaching beyond techniques such as clinical interviews or “think-aloud” sessions to include activity in natural settings, as students work in pairs or groups. Ethnographic methods provide systematic ways to collect and analyze data in natural settings, which might seem daunting in their messiness. And ethnographic methods can be used to design more ecologically valid tasks for subsequent data collection using clinical interviews or ‘think-aloud’ sessions.

Ethnographic methods are not new to research in mathematics education and have been used by researchers outside the classroom (for examples see work in the references by Brenner 1985, 1998; Civil 2002; Civil and Bernier 2006; González et al. 2001; and others) as well as inside the classroom to document and study classroom activity focusing on the teachers or the learners. This chapter uses my own research as an example and thus focuses on learners’ activity in classrooms. However, there are many other ways, settings, and foci for research using ethnographic methods.

The chapter focuses on the following questions:

1. *What is a naturalistic paradigm?* What principles guide research studies using a naturalistic paradigm? How can a naturalistic paradigm be combined with other research approaches to explore questions about mathematical thinking and learning?
2. *What are ethnographic methods?* What is the difference between doing ‘an ethnography’ and using ethnographic methods? How can researchers use ethnographic methods to investigate aspects of mathematical thinking and learning? What are central methodological concepts related to ethnographic methods?
3. *How can video be used as an ethnographic research methodology?*
4. *How can we analyze student mathematical activity using a naturalistic paradigm and ethnographic methods?*

The theoretical perspective used in this chapter is based on the assumptions summarized in the chapter by Moschkovich and Brenner (2000), in which we described how to integrate a naturalistic paradigm into research on mathematics and science cognition and learning. This chapter also uses several important concepts such as a definition of context by Lave (1988, p. 462), and illustrates two concepts discussed by Moschkovich and Brenner (2000), an ethnographic stance (p. 474) and ecological validity for cognitive tasks (p. 466) (each of these is discussed in detail in Sect. 3.2 of this chapter).

The term “methodology” is sometimes misunderstood to refer only to “methods,” when, in fact, theory and methods are intricately related, mutually constructive, and informing of each other. Methodology includes the underlying theoretical assumptions about cognition and learning: what cognition and learning are; when and where cognition and learning occur; and how to document, describe, and explain them. I will use the term “methodology” to refer to theory and methods together.

The dictionary definition of paradigm is a philosophical or theoretical framework. Integrating a naturalistic paradigm into research involves using both theory and methods that reflect, or are at least consonant with, that naturalistic paradigm.

Methodology is assumed to be theory plus methods, not a collection of methods but an epistemological stance towards multiple aspects of research: Theory informs research questions, research design, and data analysis (i.e., selecting lessons, transcribing, focus for different analyses). For example, video or interviews are not techniques but data sources that can be used from multiple theoretical stances. Similarly, data collection or analysis techniques such as discourse or protocol analysis are also framed by a researcher's stance or paradigm. Research design decisions depend on having clear and focused research questions and imagining what data would look like that might answer particular research questions. Since no researcher or research study can cover everything, each study needs to focus on what that one study can do well.

3.2 A Naturalistic Paradigm¹

Ethnographic methods are framed by a naturalistic paradigm, which is different than that of experimental design. However, the design and analysis processes are still systematic and have to be consistent with the theoretical framing for a study. In the chapter by Moschkovich and Brenner (2000), we described a naturalistic paradigm as follows:

The naturalistic paradigm that undergirds our work is an emergent paradigm about the nature of the research enterprise (Lincoln and Guba 1985; Erlandson et al. 1993). This paradigm arose in contrast to positivistic traditions in which the scientific method was considered the route to discovering an objective reality. The naturalistic paradigm assumes that meaning is constructed by both participants and observers so that, in effect, there are multiple realities (Erlandson et al. 1993). Because these multiple versions of reality are shaped by both theoretical and value frameworks, it is not possible to achieve pure objectivity. (Guba 1990). (p. 459)

We also described the goal of the naturalistic research enterprise according to Guba (1990) as follows: “to identify the variety of constructions that exist and bring them into as much consensus as possible” (p. 26). To fulfill this purpose, naturalistic research takes a holistic view in order to examine these various constructions in relation to each other as they interact in their own contexts. Naturalistic research is not synonymous with qualitative research, although qualitative methods tend to be the preferred methods used in the naturalistic paradigm (Erlandson et al. 1993; Guba 1993), the naturalistic paradigm is inherent in some qualitative traditions, but not all (for more details see Jacob 1987).

Using this paradigm implies that design and analysis are conducted from an ethnographic stance, that context is defined as a complex, multifaceted, and interactional phenomenon and that design considers the ecological validity

¹This section is largely based on a previous publication co-authored with M. Brenner (Moschkovich and Brenner 2000).

(Bronfenbrenner 1977; Cole et al. 1978) for mathematical tasks used in a study. In the next sections I address each of these three aspects of a naturalistic paradigm.

3.2.1 *An Ethnographic Stance*

The theoretical stance can be summarized as the assumption that meaning is socially constructed and negotiated in practice. The research principles include considering multiple viewpoints, studying cognition in context, and connecting theory generation and verification. It is important when using ethnographic methods not to simply use the methods divorced from the naturalistic paradigm that frames these methods.

Naturalistic and cognitive (or experimental) methods can be combined in complementary ways and can be integrated into mathematics education studies, but this integration and combination must be carefully considered during all aspects of research, designing a study, collecting data, and analyzing data. For example, the mathematics content of most interest may not always be visible in “natural” settings, so researchers may need to combine data from a “natural” setting and a more structured situation that includes an intervention, a quasi-experiment, or a design experiment (Brown 1992). Nonetheless, to understand the process of learning from the naturalistic research stance, it is essential to include at least some data from a “natural” setting, such as a classroom or other complex setting, in the research design. The third section of the chapter describes this design process in more detail.

A naturalistic paradigm is not defined by the methods used or the place where data are collected but, more importantly, by a theoretical stance and a set of research principles. The theoretical stance assumes that meaning is socially constructed and negotiated in practice and uses several research principles such as considering multiple viewpoints, studying cognition in context, and connecting theory generation and verification. This stance and these principles do not exist on their own; they are tied in complex ways to several disciplines and traditions and draw meaning from these disciplines. A naturalistic paradigm and the accompanying ethnographic methods are couched within the practices of an academic discipline also and take their meaning from these practices.

A naturalistic paradigm and an ethnographic stance can be summarized by the following principles: (1) Consider multiple points of view and (2) Study cognitive activity in context. These two principles derive from ethnography, a methodology (not a collection of methods) connected closely to the theoretical principles of anthropology, such as the centrality of the concept of culture (Spindler and Spindler 1987). Definitions of culture² are contested and vary across academic disciplines.

²There is no one definition of culture, however anthropologists typically agree that it involves learning that people do as members of human groups as they learn to “interpret experience and generate behavior (Spradley 1979), that it is an action or a process, not a thing, and that it includes both explicit (reported) and tacit (common sense, not reported directly) meaning making. Here I

A definition of culture or an account of debates around its definition is beyond the scope of this chapter. However, educational anthropology and cultural psychology provide some assumptions to ground studies in mathematics education.

First and foremost, we cannot assume “cultural uniformity or a set of harmonious and homogeneous set of shared practices” (Garcia and González 1995, p. 237) about *any* cultural group. To avoid ‘essentializing’ cultural practices Gutiérrez and Rogoff (2003) propose that we focus not on individual traits but on what they call “repertoires of practice” using the assumptions that individuals develop, communities change, and learners have access to multiple practices. They argue that we should “neither attribute static qualities to cultural communities nor assume that each individual within such communities shares in similar ways those practices that have evolved over generations” (Lee et al. 2003).

3.2.2 *Ecological Validity*

Ecological validity in psychological studies (Bronfenbrenner 1977; Cole et al. 1978) ensures that participants’ reasoning is examined on cognitive tasks that are connected to regular cultural practices, in or out of school. Cultural psychology has shown that, when this is not the case, participants look less competent than they actually are (Cole et al. 1978). It is most important to use ecological validity when designing cognitive tasks,³ as described by Cole et al. Bronfenbrenner (1977) suggests that for a study to be considered ecologically valid it should be designed to meet three conditions:

First, it must maintain the integrity of the real-life situations it is designed to investigate. Second, it must be faithful to the larger social and cultural contexts from which the subjects came. Third, the analysis must be consistent with the participants’ definition of the situation. (p. 35)

Cole et al. (1978) recommend that “the analysis of any behaviour should begin with a descriptive analysis of at least one real world scene” (p. 4). This descriptive analysis informs the design of experiments (or quasi-experiments) that preserve some aspects of the real-world setting while modifying others. A study can start with observations in a setting where cognitive phenomena occur regularly without intervention. To explore further the cognitive phenomena observed in the natural setting originally, researchers then design interviews, quasi-experiments, tests, and interventions, based on those observations.

am not referring to culture as a factor or a variable (such as socioeconomic status, ethnicity, or gender) but to the concept of culture: the assumption that everyone participates in multiple cultural practices and that these cultural practices play a role in thinking, reasoning, and learning.

³The design of ecologically valid mathematics tasks is addressed in detail in other publications (i.e. Lave 1988; see Moschkovich and Brenner 2000 for other references).

When considering whether a task is ecologically valid, context is not assumed to be a unilateral experience. Traditional task analyses of mathematics problems conducted by experts assume that learners know what experts know and thus use an impoverished notion of context, defined by how an expert sees and interprets a task. In contrast, a more complex notion of context adds depth to how we see and interpret mathematical tasks.

3.2.3 Context

Lave (1988) provides a definition for *context* and distinguishes it from the *setting*. For Lave, a setting is the physical and social environment.⁴ A description of a setting includes the objects, people, and activities that are present. In contrast, Lave defines context as the relationship between a setting and how participants interpret the setting, including how participants interpret, view, or understand artifacts (documented by how participants use and/or communicate about their activity with an artifact). A description of context would analyze more deeply the different interpretations or views that a setting and an artifact (as well as the practices that take place in a setting) may have for different participants.

A description of context delves more deeply into the *different meanings that a setting and the practices taking place in a setting have for different participants*. Context is thus not a single entity, such as a place, but instead it is:

... an identifiable, durable framework for activity, with properties that transcend the experience of individuals, exist prior to them, and are entirely beyond their control. On the other hand, context is experienced differently by different individuals. (p. 151)

For example, using Lave's (1988) definitions of context and setting, an algebra word problem is an artifact—not a context—that can create or support different contexts; such contexts depend on how different people, for example, understand or view an algebra word problem in person:

- A kinder-gardener may view an algebra words problem as a bunch of scribbles on a page.
- A high school student may see a word problem as a task to solve using practices learned in school, other ways that a high school student might understand or view an algebra word problem would include affective aspects of activity, such as a negative or positive emotional reaction, depending on that student's past experiences with word problems.
- A mathematics instructor might see or view an algebra word problem as a way to show their students how to apply an important mathematical idea or technique to a concrete situation.

⁴Lave uses the term “arena” to refer to “setting” and defines “setting” as the “repeatedly experienced, personally ordered and edited version” (Lave 1988, p. 151) of an arena.

One way to address the importance of context is to study mathematical thinking and learning in the settings in which it naturally and regularly occurs without intervention. The naturalistic paradigm and ethnographic research methods were developed to study activity within such “natural” settings and here they have much to offer mathematics education research. A naturalistic paradigm provides a road map for understanding learners in their own terms and highlighting the potential in what they know, rather than only comparing their knowledge to that of an expert, and analyzing the unexpected structure of novices’ knowledge, the alternative understandings held by learners (Confrey 1990), or the potential for progress in students’ initial conceptions (Moschkovich 1992, 1999).

3.3 Research Design Issues for Ethnographic Data Collection

In this section I summarize issues to consider for ethnographic data collection. Even if the research design is not full blown ethnography, a study can use a mixed tool kit that includes some ethnographic methods such as participant observation or open-ended interviewing. First, a note that using ethnographic methods is not the same as writing an ethnography and that an ethnography involves much more than using ethnographic methods (Moschkovich and Brenner 2000):

Ethnography is a methodology that is intricately related to the theoretical principles of anthropology, such as the centrality of culture:

...many people, who are quite innocent of anthropology as a discipline and who have only vague notions of cultural process, claim to be doing ethnography. We have nothing against anyone doing qualitative, field site evaluation, participant or non-participant observation, descriptive journalism, or anything else if it is well done. It will produce some tangible result and may be useful, but it should not be called ethnography unless it is, and it is not ethnography unless it uses some model of cultural process in both the gathering and interpretation of data. (Spindler and Spindler 1987, p. 151)

A central question to consider in designing a study is what types of research questions can be answered with ethnographic methods and what types cannot be answered with ethnographic methods. For example, in contrast to experimental design, ethnographic methods cannot answer cause and effect questions but leave room for new research questions as they emerge during a study. Participant observation can also shape or focus the research questions asked (as well as inform the design of interviews or cognitive tasks for clinical interviews).

Other design issues for ethnographic data collection include the following:

- (1) When will classroom data be collected or what will be the time frame? For example, during the first weeks of a school year it is suitable to look at how the ‘culture’ of the classroom is established, or later in the year, how does the classroom culture appear once the classroom routines have already been established?

- (2) Will the unit of analysis be a full topic or a full curriculum unit?
- (3) How much data will be collected? How will decisions be made about how much data will be enough⁵?
- (4) Who or what is the focus of the data collection: the teacher, groups of students, individual students, the whole class, etc.?

One of the central goals of using ethnographic methods is to identify the issues for the participants (Spradley 1979). However, ethnographic methods also help the analyst to raise issues that the participants may not have been aware of themselves. There are many different ways to collect data when using ethnographic methods. Two broad ethnographic methods used for data collection are participant observation and open ended interviewing. Important distinctions are the differences between what people say they do (self-reports, interviews), what people are observed doing (observation), and what the researcher concludes from participation in an activity (participant observation).

Other design issues include making decisions about what supporting data are needed to answer the research questions, for example, copies of student work, hand-outs, student grades, test scores, etc. The design also needs to consider what kind of background information will be collected on students or teachers. If interviewing, decisions will need to be made regarding whether it will happen daily, after a natural grouping of data, group debriefing, etc. and whether the interviews will be clinical interviews, pair discussions, group discussions after taping, etc. If interviews are conducted with students, then decisions will need to be made about the tasks used (i.e. complementary cognitive tasks, ecologically valid tasks, etc.).

3.4 Video as an Ethnographic Research Methodology

Using video data to document mathematical activity is more than a matter of using a particular research method, it is a matter of methodology. Like other methods, video is a research method that is theory laden and that can be used from multiple theoretical stances. Uses of video data as an ethnographic method are multiple and varied. Video can be used to record, examine, and analyse many different types of phenomena and for multiple purposes. The data collection and analysis can focus on children's activity (i.e. mathematical explaining, engagement, etc.), or on examining patterns or trends in teaching practices, or record and examine participant structures in a classroom. Some researchers archive video data for a second analysis at a later time. In the next section I focus on issues involved in using video to document mathematical activity among learners, and describe some issues particular to using video.

⁵A useful concept is data saturation (Glaser and Strauss 1967; Strauss and Corbin 1990).

3.4.1 Advantages and Disadvantages of Using Video Data

There are both advantages and disadvantages to using video data. Video data have several advantages when used to document learning and teaching. Video data may capture “more” of what happens in a classroom than other forms of data collection such as student and teacher self-reports, interviews, or questionnaires. Video data make it possible to capture both teacher and student activity, sometimes simultaneously. Overall, video data have the potential to capture more than what one set of eyes and ears can notice and record in real time.

However, video data also have disadvantages for documenting learning and teaching when compared to other methods of collecting data. Video data capture ‘less’ of what happens in a classroom than other forms of data collection because the researcher must make choices that limit what is and what is not recorded. Researchers choose whether to pan across a room, focus on the teacher, focus on students, or fix on one group of students. In contrast to observations, what activity is captured and what activity missed, is determined by camera location, rather than a trained observer’s reaction to events as they unfold. It is important to remember that video data, like any other type of data, have limitations. Video data are not equivalent to direct observational data nor do they provide an ‘objective’ or ‘realistic’ view of a setting or the activity in any setting. Video data reflect deletions and selections, capture only one particular perspective, and this perspective is one that no participant could have had (Hall 2000) and the analyst decides what perspective to present (Goldman 2014).

Researchers working from a naturalistic paradigm (Moschkovich and Brenner 2000) recommend that video data not stand alone but instead be interpreted and framed by other kinds of data. Other types of data such as observations, field notes, supporting materials, and contextual information are necessary for making meaning for recorded video data. The analysis of classroom activity needs to be couched and framed by other types of data: the teacher’s goals, textbook use, district policies, preceding lessons, information about the students, etc., and this is especially important for cross-cultural work:

Contextualizing recorded behaviour is important in understanding the meaning behind that behaviour, and it is especially important when coding across cultures (Erickson 1986). Similar behaviours may have different meanings and comparisons can be problematic. (Ulewicz and Beatty 2001, p. 13)

Several problems have been documented when using and analysing video data (Ulewicz and Beatty 2001; Derry et al. 2010; Tobin et al. 1989). For example, viewers may sometimes develop an exaggerated sense of confidence about what they know about a classroom after watching just a short video clip (Brenner, personal communication; Tobin et al. 1989; Ulewicz and Beatty 2001, and my own personal experiences). Assessment of mathematics teaching through video data have been documented to have a tendency to focus only on negative aspects, but researchers have found that a process of social moderation or discussion along with

coding “allowed scorers to overcome their tendency to focus only on negative aspects of performance and to acknowledge positive aspects” (Frederiksen et al. 1998, p. 255).

In my own experience showing, discussing, and coding video, it is common for viewers to focus on what is wrong in a lesson or what a student is doing wrong, rather than on how a lesson is working well or what a student is doing well. Because video slows action down, every participant on tape may seem both less and more competent than in real time. As we watch video, we have more time to notice how participants mis-speak or make mistakes than we would have if we were observing in real time, thus making them appear *less* competent. As we watch video, we also have more time to notice and really think about what participants said and did, potentially making them look *more* competent than in real time. The ways that analysts perceive a participant’s competence or lack of competence is framed and informed by the theoretical framework we use to analyse video data.

3.4.2 *Transcription and Translation as Theory*

There are several stages of design decisions to make when using video as part of the ethnographic methods for a research study: collecting, preparing, describing, and analysing. Preparing video includes using content logs, writing memos, selecting segments to transcribe, and transcribing/subtitling. I will focus on issues related to the preparing stage, especially transcribing and translating, because these are crucial for using video from a naturalistic paradigm and as part of a toolkit of ethnographic methods.

Transcription and transcript quality are heavily loaded with theory (Ochs 1979; Poland 2002). Researchers make many decisions about transcripts that are based on their theoretical frameworks and on the particular research questions for a study. For example, decisions regarding what to include in transcripts and which transcript conventions to use are informed by theory. Whether a transcript will include or not gestures, emotions, inscriptions, body posture, and description of the scene (Hall 2000; Poland 2002; McDermott and Gospodinoff 1978), will depend on whether these aspects of activity are relevant or not to the particular research questions. Similarly, selecting transcript conventions and deciding whether overlapping utterances, intonation, and pauses are included or not in a transcript depends on whether these aspects are relevant to the research questions and analysis for which the transcript and video will be used. And whether and how aspects of activity are relevant (or not) to the research questions depends on the theoretical framework. Rather than asking whether a transcript is done, finished, or complete, we should first ask what purposes and research questions the current transcript is serving and what theoretical perspective frames the study. Only then can we decide whether the current transcript is sufficiently detailed (in terms of what information it includes)

and systematic (in terms of how this information was recorded and represented) for those specific purposes and research questions.⁶

Two aspects of conversations and features of talk that may be relevant to documenting mathematical activity are intonation and the use of gestures.⁷ Perceiving a student as uncertain or hesitant because of intonation patterns may have an impact on how both researchers and teachers perceive student contributions in mathematics classrooms. For example, intonation patterns vary across languages and among dialects:

Perhaps the most prominent feature distinguishing Chicano English from other varieties of American English is its use of certain intonation patterns. These intonation patterns often strike other English speakers as uncertain or hesitant. (Finegan and Besnier 1989, p. 407)

Translation presents a challenge all its own. Translation is not simply a copy of the original utterance but in another language. Translating between national and social languages necessarily involves interpretation. It seems impossible to translate without putting some piece of ourselves in the new utterance—translators are not simply empty vessels when we translate. There seems to be no way to translate an utterance and be certain that the original utterance carried *exactly* that meaning.

When participants use two languages, it is important for researchers to decide how to display translations. There are several reasons that make it crucial that the original utterances be displayed regardless of the language of these utterances or whether the intended audience speaks that language. First, the original utterances need to be available for inspection so that the analysis and the translations are transparent to all readers. The choice of whether they appear in the text of an analysis or in an appendix is up to the analyst. Second, displaying only translations privileges the language of the translation (usually English for international publications) and perpetuates views of the world as principally monolingual. Subtitles can be useful (even for monolingual utterances), since not everyone can hear what the analyst hears after hours of repeated listening.

3.4.3 *Analysing Mathematical Activity*

In closing this section, I would like to raise an issue related to analysing mathematical activity using video, a focus on the negative aspects of human activity in video data and *how* we use video data to document learners' mathematical activity. The focus on the negative when looking at videotapes is a danger that applies not only to analyses of teaching but also to how we view learners' mathematical

⁶Transcript quality ranges over a wide spectrum and transcripts need to be labelled according to the stage of development. I have used labels such as rough transcript, working transcript, and "done for now" transcript, because a transcript is never really finished.

⁷Students' use of gestures to convey mathematical meaning has been documented in multiple studies (for example De Freitas and Sinclair 2012; Edwards 2009; Edwards et al. 2009).

activity. It is a common experience for viewers to focus on what a student is doing wrong, rather than on what a student is doing well. Because a focus only on negative aspects or performance has been documented as a problem when looking at videotapes (Frederiksen et al. 1998), video data should be used carefully to document competence, proficiency, or other evaluative analysis of either teacher or student activity.

3.5 Analyzing Mathematical Activity Using a Naturalistic Paradigm and Ethnographic Methods

In this section I use my own work as one example of a way to analyse student mathematical activity using a naturalistic paradigm and ethnographic methods⁸ and focus on describing how I have used an ethnographic stance and ecological validity to design mathematical tasks.

3.5.1 An Ethno-Mathematical Perspective as an Example of an Ethnographic Stance

I use an ethno-mathematical perspective (a particular version of the more general ethnographic stance described earlier) to frame the description of mathematical activity among bilingual learners. An ethno-mathematical perspective expands the kinds of activities considered mathematical beyond the mathematics found in textbooks or learned in schools (D'Ambrosio 1985, 1991; Nunes et al. 1993). This perspective emphasizes that “mathematical activity” is not a unitary category but is manifested in different ways in different settings. Moreover, mathematical activity is not always immediately evident to the participants or the analyst but, instead, is uncovered during analysis. Using this perspective focuses data analysis on uncovering the mathematical structure in what participants are *actually* doing and saying. It focuses the analysis on specifying what mathematical concepts and conceptions students are grappling with, even when these mathematical concepts and conceptions may not be immediately evident to participants or sound like textbook definitions of academic mathematics, thus making students’ own mathematical activity more visible. Taking an ethno-mathematics stance means that students’ mathematical activity in the classroom is seen not as a deviant or novice version of academic/school mathematical practices but instead as a particular case of students’ everyday activity, where participants use social and cognitive resources to make sense of situations.

⁸For more detailed examples see Moschkovich (1996, 1998, 2008, 2011).

When focusing on mathematical reasoning (Moschkovich 2011), I have used several criteria for selecting segments to transcribe:

- *Mathematical topic, problem or task*: I select all segments where student activity focuses on a particular mathematical topic, problem, or task.
- *Mathematical concepts and conceptions discussed*: Sometimes students discuss and use mathematical ideas other than those intended in the problem or task. For example, I select all segments where student seem to use proportional reasoning, even if that was not the intention of the problem.
- *Mathematical discourse activity*: I select all segments where students were engaged in a particular discourse activity such as explaining, comparing answers, disagreeing, etc.
- *Markers of understanding*: I select segments where participants themselves mark that they understand or don't understand, for example saying "I really get this now! Or "I don't get this..."
- *Communication breaks down*: I select segments when communication seems to break down and participants say, for example "What do you mean?"

Below are some questions I have used for analysing mathematical activity:

1. Are students participating in mathematical practices? If yes, which ones?
2. Does student activity reflect mathematical competence? If yes, which aspects of mathematical competence does student activity reflect?
3. Are there any "big" mathematical ideas evident in student activity (students need not be conscious of the mathematics themselves)? If yes, which ones? If not, which "big math ideas" do I see as relevant to this discussion?

3.5.2 Two Studies as Examples of Using an Ethnographic Stance and Designing Ecologically Valid Tasks

The typical design for my research projects is a cycle that combines classroom observation and discussion between pairs of students. The central design is a cycle of classroom observations for several weeks, videotaping lessons and small groups, designing ecologically valid tasks for what I call "peer discussion sessions," and videotaping those discussion sessions between pairs of students outside of the classroom. The discussion session problems are designed to be ecologically valid and target conceptions documented in the classroom observations. The "peer discussion sessions" are structured to support dialogue and discussion of not only answers but also conjectures, predictions, and justifications. This design cycle is based on studies of mathematics at work, for example tailors in Liberia (Brenner 1985, 1998; Lave 1997), but I use it to study mathematical reasoning in school.

The classroom data collection includes long term classroom observations (4–6 weeks minimum). I use those observations for multiple purposes: to get to know the students and the teacher, document and understand classroom routines and practices, document mathematical reasoning in the classroom, generate my own conjectures about student conceptions, and as the basis for designing ecologically valid tasks that target conceptions documented in the classroom observations. I also video tape whole class discussion and selected small group conversations for one or two focus small groups. I work in close collaboration with the teacher in making many of the design decisions.

The peer discussion sessions are for pairs of students who work on problems targeting student conceptions documented in the classroom. The students produce written work and their discussions are video-taped. These peer discussion sessions provide a quieter setting for data collection, a task focused on particular ideas, and structured discussions.

For this research project, I collected a large set of data in an eighth-grade bilingual mathematics classroom. The class was conducted mostly in English, with some discussions and explanations in Spanish. The teacher used Spanish mostly when she was addressing students who were seen as Spanish dominant. Some students spoke mainly English, some students used both languages, and some students spoke mainly in Spanish.

Classroom observations and videotaping were conducted during two curriculum units from *Connected Mathematics*, “Variables and Patterns” and “Moving Straight Ahead.” Data collected included videotapes of whole-class discussions and at one student group for every lesson, as well as videotaped problem-solving sessions in pairs. I analysed one classroom discussion that occurred during the unit “Moving Straight Ahead” (Moschkovich 2008) between two students, Carlos and David, and their teacher. For that analysis, I focused on two classroom discussions, one in their small group and another a few months later as a whole class. Although the analysis focused on the transcripts from those two discussion, I used the long-term classroom observations and field notes to develop an overall sense of the classroom, to contextualize the two students’ work on those two days, and to document the source of local ways of talking about the graphs.

For example, I describe this class as one where students expected to make sense of their work, discussed their work with peers, and also used the teacher as a resource in their discussions. Students took on some of the responsibility for explaining and understanding solutions and engaged in serious and extended discussion of their solutions. The small group discussions seemed to be important to the students. Nevertheless, while the students shared responsibility for explaining solutions, they sometimes also tended to rely on the teacher as the authority for evaluating a solution.

The teacher and students used multiple meanings for the phrase “I went by...” to describe the scales on graphs (e.g., ‘I went by ones’ or ‘I went by twos’). Using an ethnographic stance, the analysis focused on the ways that the participants themselves used those phrases, not on any one canonical meaning. The graphs, verbal descriptions, gestures, and the multiple meanings generated during the discussion

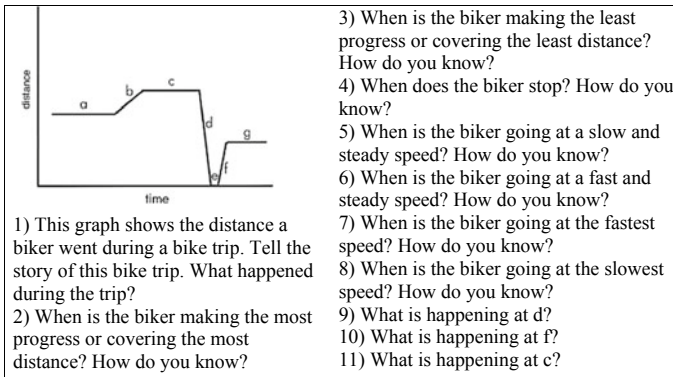


Fig. 3.1 The problem students discussed in pairs

were all resources for socially constructing interpretations of the graphs. These phrases and their meanings were locally situated, not only in this particular discussion, but also in the history of the classroom and lesson. The classroom observations (and observations in other classrooms) provided the data necessary to contextualize those phrases as not just used by these two students and as not just unusual or strange but part of the local classroom ecology.

For another analysis, I used only the peer discussion data, but that analysis was still informed by the classroom observations. In that paper (Moschkovich et al. 2017), we analyzed eight peer discussion sessions that involved four pairs of bilingual students (two discussion sessions per pair). During the peer discussion sessions, pairs of students answered questions about a distance versus time graph and an imagined bicycle trip.⁹ The students were working on a problem with twelve questions about a distance vs. time graph depicting the motion of an imagined biker (shown in Fig. 3.1). The first question asked the students to tell a story about a bike trip corresponding to the graph. Questions two through eight asked students to identify when the biker was going fastest, slowest, or stopped. Questions nine through twelve asked what was happening for particular segments of the graph.

This paper is an example of using an ethnographic stance, in this case to analyze not classroom data but the data from pair discussion outside of a classroom using an ecologically valid task. For the analysis, we used the pairs as the unit of analysis, coded video with transcripts for student conceptions, counted and summarized conceptions for each pair, and made comparisons across pairs of students. Using an ethnographic stance, the chapter describes how pairs of students generated multiple interpretations of the horizontal segments on the graph in Fig. 3.1, a distance-time graph depicting the motion of a biker. Assuming the biker moves along a line, all horizontal segments on this graph represent that the biker was stationary. In this

⁹While the student pairs worked together on the task, the first author of the paper observed silently and then asked follow-up questions in order to clarify student responses and understand students' assumptions about the goals of the task.

analysis we found that, while students consistently interpreted the horizontal segment located on the x -axis (labeled e) as representing the biker *not moving*, sometimes they interpreted the other three horizontal segments (a , c , and g), representing that the biker was *not moving* and, other times, as *moving*. We did not view any of these alternative interpretations of the segments as misconceptions. Instead, we showed the reasoning behind these interpretations and described how students shifted among contradictory interpretations depending on the affordances and constraints of the problem. We described how students interpreted horizontal segments and then examined how the graph and the written text mediated the students' contradictory interpretations.

This problem was designed by J. Moschkovich using a graph adapted from *Investigations in number, data, and space*, 4th grade, "Graphs" unit (Russell et al. 1997) and questions used in this classroom's text/unit from *Connected Mathematics Project* (Lappan et al. 1998). The questions were presented in both English and Spanish. The problem was designed using both previous research and curriculum materials with several goals in mind. First, the central goal for the task was not to assess student learning during the curriculum unit but, instead, to explore student conceptual understandings, especially as they discussed their answers with a peer. Second, the problem was designed to be an ecologically valid task (Moschkovich and Brenner 2000) for the activity in this classroom. The graph and the questions were designed to parallel the form and content of questions in the units from *Connected Mathematics Project* (Lappan et al. 1998) that were used in this classroom.

The questions were constructed using terms and phrases commonly used in the classroom and in the unit text, such as "steady pace," "most progress," "least progress," etc. Previous research has shown that learners face difficulties in developing qualitative understandings of graphs, so another goal for the task was to elicit students' qualitative reasoning and conceptual understanding, rather than computational skills, so the graph and questions contain no numbers. Although the graph may appear "strange" (the trip does not start at the origin, segment d can be interpreted in multiple ways), these aspects of the graph are not considered defects of the task design, but instead, as characteristics of an interesting, challenging, and open ended task hypothesized to generate multiple conjectures and stimulate discussion between the students solving the problem.

The introduction to the peer discussion sessions included a description of the guidelines for how the student pairs were to discuss and record their responses. The students were instructed to provide answers and explanations for each problem. To structure dialogue and discussion, the students followed an instructional sequence similar to the Itakura method for classroom discussions in science (Hatano 1988; Inagaki 1981; Inagaki and Hatano 1977). Students were asked to discuss their answers and agree on an answer with their partner before writing their final answer on paper. To promote the discussion of different conjectures, students were told that they did not have to agree on their initial choices, and that their individual choices

would be recorded on the videotape, but that they had to agree on their final answers.

Each pair participated in two peer discussion sessions, separated by approximately eight weeks, where they worked on the problem in Fig. 3.1. Each session lasted between 45 min and 1 h. During the interval between discussion sessions, these students participated in an eight-week curriculum unit on graphing and everyday motion from *Connected Mathematics Project* (Lappan et al. 1998) titled “Moving Straight Ahead.” The peer-discussion sessions were videotaped, transcribed, and coded. Students’ written work was collected and included in the analysis.

For the purpose of that analysis, we treated the pair of students as the unit of analysis. In order to describe how pairs of students interpreted horizontal segments in the graph, we compared what students wrote as their final answer on a shared answer sheet with the video and transcripts of the discussion that took place between students as they worked towards consensus. In that analysis, we focused on the students’ interpretations of the horizontal segments a , c , e and g , not only because different pairs interpreted these segments differently, but also because within each pair, the statements students made about horizontal segments were often conflicting.

Since mathematical reasoning activity involves coordinating multiple semiotic resources, the analysis included attention to the variety of semiotic tools that students used such as the graph, the written text, student’s written responses, and spoken language (including terms referring to parts of the graph, terms used during classroom lessons, and terms borrowed from the text in the written questions). Finally, we found that in order to understand how the student pairs were interpreting horizontal segments in the graph, it was crucial to understand the problem context not as a given (or from an expert’s perspective), but from the students’ perspective and as co-constructed by the pair.

The development of our coding scheme for analyzing the students’ discussion was motivated by a concern with staying “close” to students’ interpretations, a focus on the specifics of how student interpretations were mediated by a particular problem context, and an emphasis on interpretation as a productive reasoning practice. The first stage of our three-step coding process involved identifying and paraphrasing utterances that referred to any of the seven labeled line segments of the graph. At this stage, in order to increase reliability, the second and third authors coded utterances independently and then compared codes. The three authors discussed any uncertainties in coding, revisited any discrepancies, and reviewed transcript coding in conjunction with the original video data. Only utterances that were clearly referring to a particular segment were retained in the analysis. The second stage involved compiling paraphrased utterances that could be attributed to each of the horizontal line segments on the graph (segments a , c , e , and g , where our definition of “horizontal” is “parallel to or on the x -axis”). The third stage involved deriving and using two super-ordinate headings to group clusters of utterances. For example, the responses “stayed where he was” and “didn’t move at all” and “he stopped” were clustered under the heading *not moving* and responses

such as “started going again” or “going fast and steady” were clustered under the heading *moving*. After coding, clustering, and quantifying student utterances by pairs, we returned to the transcripts, video, and written data to examine in more detail any relationships between these clustered target utterances and the problem context associated with these utterances, to uncover what elements of the problem context students were referring to.

3.6 Learning to Use Ethnographic Methods

In closing, I suggest several ways that early career researchers can learn to use ethnographic methods for research in mathematics education. Although reading foundational texts is necessary, it is not sufficient. Reading can be supplemented by taking a methodology course, but that is also not enough. The optimal way to learn and develop expertise is to apprentice with mentors or more experienced peers. One can also collect tips from experienced researchers and listen to their stories. It is important to actually work at designing a project or study that would include using ethnographic methods as part of the overall research design and have that design critiqued and improved by experienced researchers.

Below are a few suggested discussion questions to consider:

1. Collect ideas from colleagues for how novice researchers can learn to use ethnographic methods.
2. Imagine and describe a small project or study that you think could be designed using ethnographic methods as part of the overall research design.
 - (a) Focus on a few research questions and how the ethnographic methods will address those questions: What are the purposes of this ethnographic data collection, verifying or generating theory, gathering evidence, generating hypotheses, justifying a claim or claims?
 - (b) How will the ethnographic methods be combined with other methods?
 - (c) How will you make decisions regarding what ethnographic data to collect?

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