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ABSTRACT

Students need, through their school mathematical experiences, to build on and formalize mathematical knowledge gained in out-of-school situations. This study examined middle school students' perceptions of how they use mathematics outside the classroom in an attempt to learn more about students' everyday mathematics practice and to close the gap between doing mathematics in school and out of school. Middle school students (n=20) were interviewed before and after keeping a log for a week in which they recorded their everyday mathematics usage. Through the interviews and log sheets, it was found that the mathematics the middle school students perceived using outside the classroom could be classified as one of the six activities that Bishop (1988) has called the six fundamental mathematical activities (counting, locating, measuring, designing, playing, and explaining) but was also strongly influenced by their view of mathematics as school mathematics. Contains 23 references. (Author/MKR)

Examining Students' Perceptions of Their Everyday Mathematics Practice

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Examining Students' Perceptions of Their Everyday Mathematics Practice

This study examined middle school students' perceptions of how they use mathematics outside the classroom in an attempt to learn more about and build on students' everyday mathematics practice and close the gap between doing mathematics in school and out of school. Twenty middle school students were interviewed before and after keeping a log for a week where they recorded their everyday mathematics usage. Through the interviews and log sheets, I found that the mathematics that the middle school students perceived they used outside the classroom could be classified as one of the six activities that Bishop (1988) has called the six fundamental mathematical activities but was also strongly influenced by their view of mathematics as school mathematics.

Introduction

Students need in-school mathematical experiences to build on and formalize their mathematical knowledge gained in out-of-school situations. An important part of a mathematical experience in school is the guidance and structure that can be provided by a teacher to help students make connections among mathematical ideas. By building upon the mathematical knowledge students bring to school from their everyday experiences, teachers can encourage students: (a) to make connections between in-school and out-of-school mathematics in a manner that will help formalize the students' informal mathematical knowledge, and (b) learn mathematics in a more meaningful, relevant way. "Mathematics teaching can be more effective and will yield more equal opportunities, provided it starts from and feeds on the cultural knowledge or cognitive background" of the students (Pinxten, 1989, p. 28).

Cobb (1986) has noted that "cognition is context-bounded . . . the elaboration and coordination of contexts is essential to the achievement of the most general of goals, the construction of a world that makes sense" (p. 5). Since cognition is context-bounded, mathematics practice can be context specific. In other words, the way a carpet estimator solves a problem in the work context may not influence how that person reasons mathematically in another context. Suggesting that students' in-school mathematics practice and learning can and should be connected to their out-of-school mathematics practice and learning may seem to be at odds with the goals of each; however, this does not have to be the case.

There are at least two goals for mathematics classroom instruction: (a) to prepare students to deal with novel problems (both real-world types and non-real-world types), and (b) to help students acquire the sorts of concepts and skills that are useful to solve many of the sorts of routine activities people encounter in life (both real-world and otherwise). To achieve (b), it is important that students work with concepts and procedures that they can generalize. In out-of-school mathematics practice, persons may generalize procedures within a context but may not be able to generalize to another context since problems tend to be context specific. Furthermore, generalization is not usually a goal in out-of-school mathematics practice.

However, knowing and using students' out-of-school mathematics practice is important in school situations because it provides contexts in which students can make connections. Connection making is essential in constructing mathematical knowledge but at present is often absent in classrooms. As Resnick (1987) noted, "The process of schooling seems to encourage the idea that . . . there is not supposed to be much con[illegible] between what one knows outside school and what one learns in school" (p. 15).

In order to help students connect doing mathematics in school and doing mathematics out of school, we need to know how students use and perceive how they use mathematics in everyday situations. To that end, the research study discussed here was conducted to gain some insight into how middle school students perceive that they use mathematics in out-of-school situations.

Recent Research

Research in the last two decades has indicated a burgeoning interest in examining the mathematics practice of people in: (a) *distinct cultures* (e.g., Gerdes, 1986; Posner, 1982; Saxe, 1981), and (b) *everyday situations within cultures* (e.g., Carraher, 1986; de la Rocha, 1985; Masingila, 1994; Millroy, 1992). Whereas the first body of research has tended to look at the mathematics practice of a whole culture, researchers examining mathematics practice in everyday situations within cultures have focused on one situation or work context (e.g., grocery shopping, carpet laying).

Mathematics practice in distinct cultures has been termed ethnomathematics. The following are two researchers' views of what is ethnomathematics.

> Ethnomathematics refers to any form of cultural knowledge or social activity characteristic of a social and/or cultural group, that can be recognized by other groups such as "Western" anthropologists, but not necessarily by the group of origin, as mathematical knowledge or mathematical activity. (Pompeu, 1994, p. 3)

> Ethnomathematics lies at the confluence of mathematics and cultural anthropology. At one level, it is what might be called "math in the environment" or "math in the community." At another related level, Ethnomathematics is the particular (and perhaps peculiar) way that specific cultural groups go about the tasks of classifying, ordering, counting and measuring. (Scott, 1985, p. 2)

In studying different cultures, Bishop (1988) has argued that there are six fundamental mathematical activities that "are both universal, in that they appear to be carried out by every cultural group ever studied, and also necessary and sufficient for the development of mathematical knowledge" (p. 182). These six activities are counting, locating, measuring, designing, playing, and explaining; mathematics, as cultural knowledge, "derives from humans engaging in these six universal activities in a sustained, and conscious manner" (p. 183).

Closely tied to the ethnomathematics research is research about mathematics practice in everyday situations within cultures. There appear to be two common threads running through the research literature on mathematics practice in everyday situations within cultures. First, the fact that problems are embedded in real contexts that are meaningful to the problem solver motivates and sustains problem-solving activity. Secondly, in solving problems that arise or are formulated in everyday situations, problem solvers often use "mathematical procedures and thinking processes that are quite different from those learned in school. Furthermore, people's everyday mathematics often reflects a higher level of thinking than is typically expected or accomplished in school" (Lester, 1989, p. 33).

The majority of research on mathematics practice in everyday situations within cultures has investigated the use of: (a) arithmetic (e.g., de la Rocha, 1985; Murtaugh, 1985; Scribner, 1984b), (b) geometry (e.g., Millroy, 1992), (c) rational number concepts (e.g., Carraher, 1986), or (d) measurement (e.g., Masingila, 1994). These studies, in general, have examined the mathematics concepts and processes that adults use in these various contexts. Very little research has examined children's everyday mathematics practice: "Even though that field [mathematics education] calls for relevance of mathematics learned to everyday settings, there has been remarkedly little ethnographic investigation of mathematical activities by children in settings outside classrooms" (Pea, 1991, p. 490). As one step in examining children's mathematics everyday mathematics practice, I undertook the study described in this paper.

Structure and Aim of Study

My general aim in this study was to develop a better understanding of mathematics practice in everyday situations. To this end, I focused my attention on middle school students' mathematics practice in out-of-school situations. More specifically, this study had the following aim: To gain insight into how middle school students perceive that they use mathematics in out-of-school situations.

My previous research has focused on (a) determining the mathematics concepts and processes used by adults in a number of work contexts (carpet laying, interior design, retailing, restaurant management, dietetics), and (b) comparing how secondary students approached problems from these contexts with how the workers approached these problems. Whereas my previous research concerning mathematics practice in everyday situations involved adult work contexts, in this study I examined children's perceptions of their mathematics practice in a variety of out-of-school settings.

Several conceptual, theoretical, and methodological frameworks guided the conceptualization, design, and conduct of this study: a cultural framework of ethnomathematics, an epistemological framework of constructivism, a cognitive framework of activity theory, and a methodological framework of interpretivism.

In this study I considered mathematics practice from an ethnomathematics approach, that is recognizing the influence that sociocultural factors have on the learning and use of mathematics (Scott, 1985). This framework influenced me to examine students' (perceived) use of mathematics in social and cultural contexts—the contexts in which the students participated in their everyday activities.

This study was also guided by a constructivist approach to the acquisition of knowledge: All knowledge is constructed by the individual and mathematical knowledge is "constructed, at least in part, through a process of reflective abstraction" (Noddings, 1990, p. 10). Furthermore, the construction of knowledge is intimately connected with its sociocultural context: "meanings and actions, context and situation are inextricably linked and make no sense in isolation from one another" (Eisenhart, 1988, p. 103). This framework influenced me to examine how students make sense and gain knowledge of their perceived mathematical activity in their everyday activities.

To focus on students' mathematical activity in everyday situations, I used the theory of activity as a guiding framework. The theory of activity has its origins in the work of Vygotsky. Activity theory is a "theoretical framework which affords the prospect of an integrated account of mind-in-action" (Scribner, 1984a, p. 2). Instead of studying psychological entities such as skills, concepts, information-processing units, reflexes, or mental functions, the theory of activity focuses on the unit of activity. One of the key characteristics of an activity is that it "is not determined or even strongly circumscribed by the physical or perceptual context in which humans function. Rather, it is a sociocultural interpretation or creation that is imposed on the context by the participant(s)" (Wertsch, 1985, p. 203). This framework influenced me to focus on students' activity and how mathematics might be a part of that activity.

I used a framework of interpretivism to guide the methodology of this study. At the heart of interpretivism is the idea "that all human activity is fundamentally a social and meaning-making experience, that significant research about human life is an attempt to reconstruct that experience, and that methods to investigate the experience must be modeled after or approximate it" (Eisenhart, 1988, p. 102). This framework influenced me as I selected data collection and analyzing methods.

Methods and Data Sources

This study consisted of three phases. In the first phase of the study, 20 middle school students were interviewed to determine their perceptions of their everyday mathematics practice. Ten eighth-grade students and ten sixth-grade students participated as respondents. Five of the eighth-grade students and five of the sixth-grade students were from an urban school and the ten other students were from a suburban middle school. The respondents were asked questions such as, "How do you use mathematics outside the mathematics classroom?" "Describe a situation where you use mathematics outside the mathematics classroom." "What do you think mathematics is?" The interviews were audiotaped and later transcribed.

During the second phase, following the interviews, the 20 respondents and other volunteers from their classes kept a log for a week to record their use of mathematics outside the mathematics classroom. A total of 69 sixth-graders and eighth-graders kept logs for a week. The directions were simply to describe how and where they used mathematics. Students were given a new log sheet each day to record their observations for that day.

After the students kept logs for a week, I analyzed the logs and categorized their mathematics usage. I also analyzed the interview comments, looking for categories of mathematics usage. In phase three I interviewed the 20 respondents again, asking them to: (a) clarify things they had written in their logs, (b) expand on earlier responses, and (c) discuss any insights they had after keeping a log for a week. Again, the interviews were audiotaped and later transcribed.

I analyzed the data through a process of inductive data analysis using two subprocesses that Lincoln and Guba (1985) have called unitizing and categorizing. I looked for units and categories of mathematics usage in out-of-school situations, changes in the students' perceptions after keeping a log, and any evidence of students making connections between their school mathematics and out-of-school mathematics.

Findings

Through the interviews and log sheets, I found evidence that the mathematics that the middle school students perceived they used outside the classroom can be classified as one of the six activities that Bishop (1988) has called the six fundamental mathematical activities. Furthermore, I found some evidence of all six activities. As mentioned previously, the six activities are counting, locating, measuring, designing, playing, and explaining.

Counting is "the use of a systematic way to compare and order discrete phenomena. It may involve tallying, or using objects or string to record, or special number words or names" (Bishop, 1988, p. 182). Examples of data reported by the middle school students that I classified as counting include: counting change in a store, estimating the prices of several items, figuring mileage for a trip, finding someone's age given her or his year of birth, calculating the amount of ingredients needed when changing a recipe to serve a different number of people, keeping score during a basketball game, comparing unit prices, counting the number of soda cans and figuring amount of money to be received, figuring tip in a restaurant, counting music measures in band.

Locating is "exploring one's spatial environment and conceptualising and symbolising that environment, with models, diagrams, drawings, words or other means" (Bishop, 1988, p. 182). Data reported by the middle school students that I classified as locating include: using a map to plan a driving route, working with a parent to use a blueprint to determine where to install some electrical wires, drawing a sketch before building a club house.

Measuring is "quantifying qualities for the purpose of comparison and ordering, using objects or tokens as measuring devices with associated units or 'measure-words'" (Bishop, 1988, pp. 182-183). Data I classified as measuring include: cutting material before sewing a shirt, estimating distance on baseball field, estimating size of hole needed for a screw, measuring parts for a rocket, comparing skating speed in street hockey with and without ball, measuring ingredients before cooking, measuring picture to determine frame size, measuring food portions, laying out measurements for club house, figuring area of garden, measuring pulse rate during track practice, helping parent measure house for siding, figuring spacing for outdoor ground lights.

Designing is "creating a shape or design for an object or for any part of one's spatial environment. It may involve making the object, as a 'mental template,' or symbolising it in some conventionalised way" (Bishop, 1988, p. 183). Examples of data I classified as designing include: designing a patio, designing a club house, carving designs out of wood, planning a flower garden, designing a rocket, creating a video project.

Playing is "devising, and engaging in, games and pastimes, with more or less formalised rules that all players abide by" (Bishop, 1988, p. 183). Data reported by the students that I classified as playing include: playing chess and considering different strategies, playing lacrosse and figuring best position to run to, playing board games and figuring what moves to make, playing Perfection and determining where to put all the pieces, playing baseball and figuring where to run to catch the ball, playing basketball, playing video games, playing Number Scrabble.

Explaining is "finding ways to account for the existence of phenomena, be they religious, animistic or scientific" (Bishop, 1988, p. 183). Data I classified as explaining include: using mathematics to figure things out in science, explaining why a model train set on the same speed goes faster on one incline than on a steeper incline, explaining why a pan of food on a larger burner heats faster than one on a smaller burner, explaining why a person will feel colder at one temperature with a certain wind speed than at a lower temperature with a lower wind speed.

During the first interviews, students generally reported two to three examples of how they perceived themselves using mathematics outside the classroom. The vast majority of the data came from the logs, with students recording from three to nine examples each day of how they saw themselves using mathematics. Relatively few new examples were reported during the second interview as most of the questions centered around clarifying what the students wrote in their logs.

In general, the students' ideas of what is mathematics did not change from the first interview to the second. Examples of student responses to this question include: "Mathematics is a subject that helps me a lot." "Mathematics is a system that you use to figure things out." "Mathematics is a way of looking at things—collecting data and using what you know to find out other things." "Mathematics is using numbers and principles to find solutions."

Although students' ideas of what is mathematics did not change, all but one of the 20 students thought that they learned from keeping the log and that it was beneficial: "I noticed that I used it [mathematics] a lot more than I thought; doing the log made me concentrate and I noticed a lot more things." "It [keeping a log] opened me up to see how much more I use it [mathematics] than I thought I did. It made me think, hey, I'm using math. Its [mathematics] is just an everyday thing and its more important than I thought." "I'd fill out my log in the evening and think back over everything I did and how mathematics was involved." "When I did my log I would sit on my porch and watch people go by and think about the people and how they use math." "[The logs] helped me think more about the subtle and less obvious places where you use math."

Discussion

Because I examined student-generated data, any analysis of the data has to consider that these are the students' perceptions of how they use mathematics outside the classroom. The gap might be very wide between their perceptions of how they use mathematics and how someone might perceive them using mathematics if that person observed them in their everyday activities since one's perception of how one uses mathematics is a function of what one thinks is mathematics.

My analysis is that the primary reason for this gap is that the students' perceptions of mathematics are generally their perceptions of school mathematics. In other words, when the students looked for examples of how they used mathematics in their everyday life, they were in essence looking for examples of how they used school mathematics in their everyday life because when they think of mathematics they think fairly narrowly of school mathematic By way of example, I noticed that during the interviews, when the students were trying to answer the question about how they used mathematics outside the classroom, they often verbalized that they were trying to think of situations that involved numbers. Several students mentioned that they think mathematics "is the study of numbers." Thus, it was quite natural for them to think that numbers must be involved in some way in their mathematics usage outside the classroom.

Some students appeared to understand that there is more to mathematics than school mathematics. One student mentioned that he used mathematics and mathematical thinking a lot but he could not articulate any specific examples that were different than ones involving school mathematics: "Its different than what we do in school—I can't explain it—but I know it is mathematics." Another student mentioned that "the logs helped me realize that I did not use math that much outside of school." It may be that she was not aware of when she used mathematics; another interpretation might be that what she saw herself doing outside of school did not resemble school mathematics and so she did not classify her activities as mathematical.

Concluding Remarks

This research is one step in the direction of closing the gap between doing mathematics in and out of school. If we can understand better how students perceive that they use mathematics outside the mathematics classroom, we can build upon that mathematical knowledge and extend and formalize it in the classroom. Talking with students and having them keep a log of their mathematics usage is one way for teachers and students to learn about how students perceive their everyday mathematics practice. However, we must still confront the fact that students' perception of their mathematics practice is influenced by what they think mathematics is—and they generally think mathematics is synonymous with school mathematics. This is the paradox that Millroy (1992) discusses: "How can anyone who is schooled in conventional Western mathematics 'see' any form of mathematics other than that which resembles the conventional mathematics with which she is familiar" (p. 11).

Millroy chose to address this paradox by becoming an apprentice in a carpentry shop so that she could describe her learning experience and recognize the mathematics involved in the carpentry work that otherwise would have been unrecognizable to her. Another way to address this is to engage the students in activities in the classroom that might change their perception of what is mathematics and this may help students to change their perceptions of how they use mathematics outside the classroom. This can be done by creating a classroom practice that has some characteristics of the students' out-of-school mathematics practice. As Saxe (1991) noted, "Teachers can engineer a classroom practice that has properties of the daily practices involving mathematics in which many children show sustained engagement" (p. 18).

Saxe has discussed characteristics that appeared to promote learning in everyday practices that he thinks can be useful in developing a classroom practice: (a) "mathematics was not a target of instruction; (b) mathematics learning served the accomplishment of pragmatic objectives; (c) artifacts shaped the form of emergent mathematical problems; (d) emergent problems displayed a range of complexity levels; (e) individuals played an active role in problem formation; (f) the solutions of mathematical problems were valued for their coherence, not for the correct use of rigidly prescribed procedures" (pp. 18-19). Saxe has made use of these characteristics in "constructing a practice consisting of a thematic board game in which children assume the roles of treasure hunters in search of gold doubloons" (p. 20).

Perhaps by engaging in ethnographic investigations of mathematical activities by children in settings outside classrooms, as called for by Pea (1991), identifying contexts that are familiar to students, and developing activities that are consistent with Saxe's characteristics of everyday practice, we can help teachers construct a classroom practice that facilitates students' connection making between in-school and out-of-school mathematics practice.

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