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How Talented Rural Students Experience School Mathematics

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ACCLAIM's mission is the cultivation of *indigenous leadership capacity* for the improvement of school mathematics in rural places. The project aims to (1) understand the rural context as it pertains to learning and teaching mathematics; (2) articulate in scholarly works, including empirical research, the meaning and utility of that learning and teaching among, for, and by rural people; and (3) improve the professional development of mathematics teachers and leaders in and for rural communities..



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How Talented Rural Students Experience School Mathematics

Introduction

Constructivist research on the learning of mathematics draws attention to the ways children and adults make sense of the discipline (e.g., Hershkowitz, Dreyfus, & Schwarz, 2001; Roth & Bowen, 2001). Many studies examining mathematics sense-making offer fine-grained descriptions of the thought processes associated with constructing mathematical meaning (e.g., Pirie & Kieren, 1992). The value of these analyses is augmented by an understanding of the ways in which context – the experiences of home, community, and classroom – situates the process of sense-making (Civil, 1994; Walkerdine, 1988; White & Frid, 1995). Little empirical work to date, however, focuses on students’ experiences of mathematics and mathematics instruction, although a small literature on beliefs about mathematics and the origins of such beliefs provides some relevant insights.

Building on this literature, the present study sought to examine how mathematically talented children in a disadvantaged rural community experienced mathematics, both as a discipline and as a school subject. Our aims were to find answers to questions such as: “What do these children think mathematics is?” “What value do they attach to the study of mathematics?” and “In what ways do classroom, home, and community experiences shape their thinking about what mathematics is and what it’s for?”

Related Literature

Beyond the realm of ethnomathematics (e.g., Eglash, 1997), few studies use an emic perspective to examine individuals' experiences of formal and informal learning of mathematics (cf. Walkerdine, 1988). A somewhat larger body of research explores related questions: what do learners and teachers believe about mathematics? How are their beliefs shaped and reinforced? Within this line of inquiry, some studies focus attention on what practicing teachers and teachers in training believe about mathematics and mathematics instruction, and a smaller body of empirical literature explores such beliefs (and belief formation) among children.

Teachers' and Preservice Teachers' Beliefs about Mathematics

Studies using various research methods (e.g., questionnaires, interviews, observation, discourse analysis) provide evidence suggesting that many teachers, irrespective of the level at which they teach, believe that mathematics is a rigid discipline with well-established procedural rules that dominate practice (Barrista, 1994; Thompson, 1984). Paralleling this belief about the discipline is a view about mathematics learning that highlights procedural learning of prescribed algorithms. As Barton (2001, p. 164) notes, for example, "the mathematical picture of fifty years ago is still present in too many classrooms: facts to be learned, topics which have become outdated, a falling back on processes which are little more than learn a routine and apply it."

Given that they view the content of mathematics as prescribed and learning as a process of memorizing formulas and engaging practice with specified procedures, teachers tend to focus on instructional techniques that promote optimal efficiency in

transmitting knowledge about definitions and algorithms (e.g., Anders, 1995). Even problem-solving and mathematical reasoning tend to be treated in formulaic ways (Ford, 1994). Based on a study of elementary-school teachers' beliefs about problem-solving, Ford concluded,

... teachers believed that problem solving is primarily the application of computational skills in everyday life. Teachers said, "...problem solving is taking everyday math skills and using them in everyday life, for example, addition and subtraction", "...solving problems that deal with all four operations... that deal with things that children do in everyday life", "...applying math skills and concepts to any given experience in life." (p. 318)

Moreover, despite the fact that their knowledge of mathematics is much more extensive, secondary school teachers, like elementary school teachers, tend to embrace the view that mathematics is primarily a process of rule-based learning rather than a process of quantitative "sense-making" (Thompson, 1984).

Similar findings have been reported with regard to beliefs about mathematics and mathematics instruction held by preservice teachers (Civil, 1992; Eisenhart, Borko, Underhill, Brown, Jones, & Agard, 1993) As a result of her work with elementary teachers in training, Civil (1992, p. 8) concluded, "the most prominent idea that all the students shared was that their role as teachers was to tell the children what to do" (p. 6); the students [preservice teachers] were firm believers in the importance of teaching rules and skills" (p. 8). According to some researchers, however, salutary changes in such beliefs have reportedly occurred when college instructors made use of innovative instructional materials and methods (e.g., Masingila & Doerr, 2002; Stump & Bishop,

2002). Nevertheless, Cooney, Shealy, Barry, and Arvold (1998) explain that “[preservice teachers’] beliefs seldom change dramatically without significant intervention” (p. 1).

Furthermore, studies of both practicing teachers and preservice teachers report some variability in beliefs about mathematics and mathematics instruction. In studies conducted by Anders (1995), Brown (1992), Kuhs (1980), Renne (1992), and Thompson (1984) some teachers held more sophisticated beliefs about the nature of mathematics and the aims of mathematics instruction than did others. In fact, although most of the teachers interviewed and observed by Renne (1992, p. 6) held beliefs that led the researcher to categorize them as “conveyors,” several exhibited greater intellectual openness and sophistication. One teacher, who was characterized as an “allower,” for example, saw mathematics instruction primarily as a set of activities through which “individual growth and development are nurtured” (p. 6). Another, a “facilitator,” viewed mathematics learning as “the construction of meaning for each student” (p. 15).

In addition to the naturally occurring variation reported in these studies, some research also suggests that intensive professional development emphasizing constructivist approaches can alter teachers’ beliefs and practices (see e.g., Arbaugh & Brown, 2002). Such instruction, however, sometimes backfires, and participants ultimately come to discredit the constructivist premises of the teacher educators or other instructors (Howley & Meadows, 1996).

Students’ Beliefs about Mathematics

Because education (appropriately) promotes transmission of cultural knowledge, change in what is taught happens slowly. Not surprisingly, therefore, beliefs about

mathematics and mathematics learning held widely among the adults in a culture are likely to be conveyed more or less intact by teachers as well as by parents when they provide explicit help to their children (Masingila & Doerr, 2002; Walkerdine, 1988). Therefore, the few studies of beliefs about mathematics held by adults who are not teachers provide insight into the conventional view of the discipline (e.g., Crawford, Gordon, Nicholas & Prosser, 1993; Furinghetti, 1993; Galbraith & Chant, 1993; Lipsey, 1973). These studies suggest that, in general, adults reach conclusions about mathematics in response to the formal instruction they themselves received. According to Furinghetti (1993, p. 37), moreover, "...the adult's image of mathematics is conditioned (unfortunately, usually in a negative direction) by the school experience of the individual in a more radical way than happens with other subjects." And that conditioning, she argues, results in two possible stances with respect to the discipline: "those who were autonomously able to elaborate mathematical ideas regret the bad approach they had in school; the others (the majority) harbour feelings of refusal and repulsion towards the discipline" (p. 37).

Studies of adolescents' and young adults' views of mathematics also reveal that their beliefs are shaped by long exposure to a rule-based version of instruction (Rector, 1993; Schoenfeld, 1985). In general, this regimen leaves students with the sense that the discipline is rigid, impenetrable, and boring (White & Frid, 1995). A survey conducted by Schoenfeld (1985), for example, showed that high school geometry students, while parroting rhetoric about the importance of mathematical reasoning, nevertheless, relied on rote memorization in order to succeed in math classes. As is the case with teachers, however, there is variability in the perspectives held by students (Carpenter, Lindquist,

Matthews, & Silver, 1983; Coe & Ruthven, 1994). Moreover, as Coe and Ruthven note, this variability seems to be associated with the type of instruction that students receive:

The evidence presented here, when compared with typifications of student beliefs in more traditional settings, suggests that students who have followed reformed curricula are more diverse in their beliefs, and that some – at least at the level of espoused belief – adopt a more critical perspective towards mathematical knowledge and show a greater appreciation of the role of enquiry in mathematical thinking and learning. (p. 108)

Despite the predominant view that mathematics holds little intrinsic appeal, students do tend to believe it is useful. Nevertheless, beyond the obvious practical uses of arithmetic, they are rather unsophisticated in their characterizations of its applicability, as suggested by the following quotes from students who participated in Schoenfeld's (1985) study:

“It is helpful in chemistry and physics.” “All of the math courses taken in high school are useful for certain professions.” “Math is useful by getting us into good colleges, and having better reasoning.” “I really don't find geometry useful at all. Algebra can help you with science sometimes.” “If you were to become an engineer or technician you need the basic rules to follow for measuring things and estimating things.” (p. 30)

These quotes reveal that many students see the value of mathematics principally in terms of the access it provides to educational and career opportunities (Schoenfeld, 1985; White & Frid, 1995). As White and Frid (1995, p. 8) conclude about the students whom they studied, “... career aspirations and the relationship of mathematics study

requirements to career aspirations was an integral component of their conceptions of mathematics.”

Interestingly, research on students’ beliefs about the basis for success in mathematics reveals two distinct sets of views. Whereas some students appear to attribute success to attentiveness, hard work, and practice, other students seem to view innate mathematics ability as the primary basis for success (Buerk, 1982; McSheffrey, 1992; Mtetwa & Garofalo, 1989; Schoenfeld, 1985). Furthermore, students tend to maintain quite constrained beliefs about what success in mathematics means (Coe & Ruthven 1994; Spangler, 1992; White & Frid, 1995). For the gifted elementary-aged children in Spangler’s study, for example, success manifested itself in rapid completion of assigned problems. For the older students investigated by White and Frid, success was construed in terms of the social importance of the careers to which mathematics provides access:

In general ... few students enjoyed mathematics for its own sake. A strong interest in mathematics was sometimes expressed in relation to career aspirations and social importance of mathematics, with enjoyment achieved through being successful in relation to these other key components. (p. 9)

Despite their limited exposure to school mathematics instruction, even young children tend to exhibit a preoccupation with rules and memorization as well as showing little conversance with the idea that mathematics might involve problem-solving, reasoning, or modeling of the empirical world (Frank, 1998; Kouba & McDonald, 1991; Mtetwa & Garafalo, 1989). Moreover, young children seem to think of mathematics almost entirely in terms of calculation, despite the fact that even the most conventional curricula and teaching methods also attend to other topics, such as measurement,

estimation, classification, and probability (Frank, 1998; Mtetwa & Garafalo, 1989).

Typically researchers explain these beliefs as the obvious product of the rule-based version of mathematics instruction to which students are exposed. According to Mtetwa and Garofalo (1989), for example,

[children's] rather artificial separation of mathematical activity into the formal and algorithmic on one hand, and the informal and common-sensible on the other, is also a by-product of our instructional practices ... the usual overemphasis of computational manipulations over quantitative reasoning. (p. 613)

One study in particular supports an extremely pointed interpretation of the dynamics that lead to a diminished and at the same time aggrandized view of mathematics. Walkerdine's (1988) post-structural analysis of the ways young children discuss mathematics with mothers and teachers presents evidence of disjunctions in the character of the discourse. Whereas mothers often use quantitative concepts in a regulatory and situated manner (e.g., telling a child during a particular meal that she cannot have *more* mashed potatoes), teachers tend to use such concepts to cultivate the production of abstract signs (e.g., asking children to identify "which is *more*, 40 or 400?"). Using examples such as these, Walkerdine posits that school mathematics engages abstract reasoning through the production of signs in a deliberate effort to decontextualize quantitative concepts and thereby to demonstrate their universal applicability. As a result, mathematics contributes to a false sense of control, to "a fantasy of an omnipotent power over a calculable universe" (p. 190). From Walkerdine's perspective, then, mathematics must remain decontextualized if it is to sustain views of

power that reinforce dominant cultural assumptions and accompanying relations of power.

Gaps in the Related Literature

Although studies of beliefs about mathematics and the learning and teaching of mathematics shed light on the mental set with which children and teachers approach their work together, they do not reveal much about the wider context that shapes the practices of mathematics learning and teaching. Clearly, however, there is reason to believe that context – represented in any number of ways, for example, as culture, ethnicity, or locale – might influence how mathematics knowledge is defined and how mathematics learning is negotiated.

According to Guberman (1999), for example, “... there is substantial evidence that mathematical knowledge varies across social classes and cultural groups” (p. 31). The existence of variability in mathematics knowledge, of course, opens up the possibility that there is also variability in experiences of mathematics, mathematics learning, and mathematics instruction. Somewhat wider than the concept “beliefs about mathematics,” the related concept, “experience of mathematics,” has rarely been explored as a phenomenon of interest to mathematics educators in the United States (but cf. McSheffrey, 1992, for a Canadian study that views the experience of mathematics more broadly as a function of gender).

Methods

Our first concern in organizing a study of rural students' experiences of mathematics was to gain access to children who could serve as informants. Therefore, we contacted a school district in a state with a number of rural Appalachian districts in order to obtain consent to conduct the study. In addition, we contacted the teacher of the gifted in that district, who agreed to allow students to be interviewed during their scheduled time in the resource center.

The teacher helped us identify participants based on predetermined selection criteria as well as helping us obtain permission from students and their parents. Sixteen mathematically gifted students were selected for the study. Criteria for selection included (1) a minimum score at the 95th percentile on the mathematics portion of the Stanford-9 Achievement Test *or* (2) a minimum score at the 95th percentile on the mathematics subtest of the Woodcock-Johnson Achievement Test.

Students were interviewed by one member of the research team, who had grown up and then later worked as a teacher in a section of Appalachia close to the district in which the informants were attending school. Interviews were conducted in a room adjoining the classroom in the resource center where the teacher of the gifted provided instruction. Although other gifted students and the teacher of the gifted were in close proximity to the interview area, they were not able to hear participants' responses nor did their proximity interfere with the interview process.

In order to structure conversations with the children, the interviewer used an interview schedule focusing on relevant issues. The interview schedule included open-ended questions to elicit information about the children's experiences with mathematics

as well as more structured questions to elicit demographic data. Both as a way to establish rapport and as a way to elicit more complete answers, the interviewer asked some questions that were not explicitly included on the interview schedule: general questions (e.g., what pets do you have?) and follow-up probes (e.g., why do you think your teacher does that?).

Each interview lasted approximately 60 minutes and was recorded on audio-tape. Tapes were later transcribed; then they were reviewed carefully by the interviewer. The interviewer also developed tables summarizing demographic data about the informants.

Each of the three researchers analyzed data from the transcripts separately, first by establishing coding categories and then by identifying themes describing relationships across categories. Following this separate work with the data, we met to discuss the themes we each had identified. Although we all agreed about the salience of the five themes discussed in this paper, we each saw the relevance of one or two other themes. Since we could not agree about their salience, these themes were dropped from further consideration. This approach to triangulation provided some assurance that the themes we report are reliable representations of the ideas contributed by our informants.

Findings

First we provide information about the county in which the study was conducted, including a brief description of the school district and its gifted program. Then we describe the students whose interviews constituted the data on which the findings are based. Finally, we discuss the five themes that represent the principal findings of the study.

Context

The context for the study was Mountain County, a rural county in the Appalachian region.¹ The mountainous landscape there is beautiful, but rugged. Virtually all of the roads are narrow and winding: difficult to travel any time and especially treacherous in the winter. The many creeks and rivers in the county make flooding a constant springtime hazard.

With an average of about 46 people per square mile, the county is less populous than it once was. During the mid-twentieth century, Mountain County was one of the busiest coal mining regions in the United States. Although its current population is only 27,000 (Census Bureau, 2000), the population reached a high of nearly 100,000 in the 1950s (Carter, 1995). Primarily because of the earlier mining boom, the county is one of the few in this Appalachian state with a heritage of significant, though still limited, racial diversity. In the 1950s, the African American population was about 24% of the county population. Of the current population, approximately 3,000 inhabitants, or about 11% of the county population, identify themselves as Black or African American.

Since the advent of automation in the mines, this county has had more than its share of poverty. The scarcity of level land restricts opportunities for commercial agriculture. Perhaps because of the terrain, few industries and even relatively few service jobs have become available to replace lost mining jobs. The county's economic history of decreasing jobs has resulted in higher unemployment as well as lower population. In 2002, the unemployment rate was about 10%.

¹ Mountain County is a fictitious name for the research site.

According to the Bureau of Business and Economic Research (Condon, Childs, & Bogdan, 2000), in 1998 the largest industries in Mountain County were state and local governments, which accounted for 31% of personal earnings. The report identified mining as still an important employer; it is the second largest industry, representing about 23% of earnings. In 1999, the county's median household income was \$16,931, compared with the state average of \$29,696. Because of low earnings and low population, the tax base to support the local schools is one of the lowest in the state.

Mountain County Schools

The school system, which serves the entire county, includes seven small elementary schools, three middle schools, and three high schools. The achievement in these schools is surprisingly good considering the economic hardship facing the county. According to the state's accountability "report card," the district's 4,800 or so students score, on average, somewhat above the 50th percentile on the nationally-normed achievement test administered statewide to assess school and district performance (WVDE, 2002).

Like most districts in the state, the Mountain County Schools provide limited services to gifted students. Although required by the state to serve gifted children in grades one through eight, many teachers choose not to refer children for testing. Some teachers and parents are reluctant to send children on the long bus ride required in order to attend the program, which is housed at a resource center in a school located in the county seat. Students who attend the program, therefore, are more likely to live close to

the town than to come from more remote sections of the county. Nevertheless, the students' average travel time between their homes and the resource center is 40 minutes.

Currently, 40 children in Mountain County attend the gifted program at the resource center. Of these, seven are African American students. The proportion of African American students in the gifted program is a little larger than the proportion of African Americans in the county population as a whole. Among students in the program, many have family incomes that are lower than the average family income in the state.

Informants

The informants were 16 gifted children²; all were included in the study because of high standardized test scores in mathematics. The children ranged in age from 7 to 14, with half in the 7-9 age range and half in the 10-14 age range. Grade levels 2 through 8 were represented among the group, with children coming to the gifted program from seven elementary schools in the district and two middle schools.

With the exception of two African-American girls, all of the other children were White. The informants consisted of 8 girls and 8 boys. Most of the children (62.5%) lived in two-parent homes, and 13 (81.3%) lived in relatively small families with two or fewer siblings. Although the district was quite poor, many of the students came from middle-class homes, with one or both parents working. Several had parents who worked as teachers or teachers' aides in the school district, and a few reported that their fathers were

² According to state regulations, children identified as gifted are those children who score two standard deviations or more above the mean on a comprehensive, individualized test of intelligence, such as the Wechsler Intelligence Scale for Children – III or the Stanford-Binet Intelligence Scale IV. To qualify for gifted education services, students must also exhibit achievement or classroom performance that demonstrates a need for special services. Children who are historically underrepresented in gifted programs must meet comparable standards, but may be provided alternative assessment methods.

employed in jobs in technical fields or in sales – jobs that required them to spend a considerable amount of time away from home.

Most of the students had spent their entire school careers within the district, with only two of the children reporting that they had ever attended school anywhere else. All reported enjoying the experience of attending school in a rural locale, citing the intimate, family-like atmosphere of their schools as the primary reason for this attitude. Although none of them had attended (or even visited) an urban school, most believed that schools in cities were likely to be larger and more impersonal than the rural schools they attended. Some thought that these larger schools might provide a more varied curriculum, with greater opportunities for field trips and other special events.

Themes

Our data revealed five themes, which, taken together, accounted for about half of the comments offered by the 16 children interviewed. Two related themes concerned the substance and value of mathematics. Two other related themes focused on the nature and quality of mathematics instruction. And a final theme concerned the support for mathematics learning provided in children's homes, especially by mothers.

The Substance and Value of Mathematics

When the children talked about mathematics, they typically demonstrated a naïve understanding of the discipline. Far from seeing mathematics as a way of expressing ideas or as a method for characterizing relationships and patterns, these gifted children instead saw mathematics principally as a set of procedures with numbers – as calculations

and algorithms. Asked, for example, if math lessons ever involved problem-solving, one eighth-grader commented, “No. It’s just math.”

Even older students who were encountering algebra saw this approach to expressing relationships mostly in terms of calculation. According to one 8th grader, for example, algebra involved “solving for variables and stuff,” and he described lessons in his algebra class as “writ[ing] rules to the math until we could remember them in our head.”

Other children characterized mathematics as, “subtracting, pluses, and times,” and “finding out what a variable is in a problem.” And, as the comments below exemplify, they tended to see practical benefits, particularly in dealing with money, from having the skills that mathematics conferred:

And if you’re not too good at math but [you have] to pay for gas and stuff ... if you had to like figure it out yourself: If a gallon was a dollar, if you had three gallons, if you didn’t know your math you may think that would be \$300. And you’d actually pay that.

[Mommy] has to figure out money that people owe her. How much Mr. M – the boss -- owes her for her for her paycheck ... how much food she’s going to buy...

Not only did the children believe that math skills would keep them out of trouble with money, they also subscribed to the view that the acquisition of mathematics knowledge would give them access to good jobs. Their understanding of how math

knowledge provided such access was, however, rather sketchy; moreover, given the materialism of so much of US society, their characterization of the need for money and for “good jobs” was down-to-earth and modest, as the following dialog indicates:

I: What do you think you’re going to do in the future with your math knowledge?

S: Probably do what my dad does.

I: So what do you want to be when you grow up? You have any ideas?

S: I don’t know what he calls what he does ... I think he makes a lot of money.

I: So why do you want money? Tell me what you’re going to do.

S: ’Cause if you lived in a house you need to pay rent and the light bill and electricity bill and car bill and everything else.

I: So if you get a good job you’ll be able to do that.

S: Yes.

Despite their rather innocent understandings about how good jobs differ from less good jobs, most of the children saw mathematics knowledge as necessary for their pursuit of career success. Typically, however, their explanations of the relationship between mathematics knowledge and career preparation seemed, on the one hand, to be vague and, on the other, to be overly optimistic.

Some students, for example, held the view that mathematics is a part of the skill set required for all jobs. According to one 14-year-old boy, math is “very important because no matter what you’re going to go into in a field ... something’s going to have to do with math.” A 13-year-old classmate reiterated the point: “Most of the jobs today require some sort of math skills, whether it be just addition, integers, yada, yada, you get the idea, everything.” And a somewhat younger girl expressed this same sentiment: “It’s

important because ... even if you were a store manager you would still have to do math and if you ... like worked on rockets or things. So like any job you get you'd have to do math."

When pressed, however, about the specific ways mathematics knowledge might fit into the careers they wished to pursue, most students revealed extremely limited understanding. Some talked about the fact that math was necessary for success in college, which was, in turn, necessary for career success. Others spoke in rather vague terms about the linkages between particular career options and mathematics knowledge. One eighth grader, for example, explained, "I know I'd like to become an optometrist. I'm not sure if I'd have to do very much math there, but I know I'd have a lot of science and I like science, too." Another of the older students commented, "Well, when I go to college I want to be a lawyer or a sports medicine doctor. And, I know sports medicine has a lot to do with science and math and stuff. I'm not sure if a lawyer has a lot to do with math or anything. But I'm sure it does in a way."

The younger children had even less well-formed ideas about how mathematics knowledge might actually be used by various professionals. They seemed to sense, though, that the interviewer as well as other adults might want them to see mathematics as useful. The story below, offered by a 9-year-old girl, provided the most farfetched illustration of a type of response given, typically in less fanciful ways, by several of our younger respondents.

I want to be a veterinarian ... And if this woman comes in with a puppy and she says, "I need some help. I need some help." And she takes [the dog] in my office and she says, "I need to know how many puppies my dog's going to have in the

next 24 hours.” And ... you’d have to know how many she’s going to have. She’ll be expecting it. And say I didn’t know how to count – say she’s going to have like 20 and say I didn’t know how to count to 20 ‘cause I never learned, ‘cause ... I always got F’s and I barely passed ... and I wouldn’t know how to do it I’d just be like, “she’s going to have five. Bring her back to me in 24 hours.” She comes back the next day. And she’s like, “okay, [the dog’s] here; she’s ready.” And so she comes down and has 20. And she says, ‘well you told me she was going to have five and now she has 20. What am I going to do with all these dogs?’ Well, she would’ve made arrangements for ... five puppies ... but what’s she going to do with the rest of them? I mean, I would say, “Oh, I’m sorry. I must’ve read the diagram wrong.” “Yeah, you read the diagram wrong, alright.” She would start fussin’, and I would get fired.

Taken together, the comments that this theme comprises suggest that, even though they had limited awareness of what mathematics involves, the children nevertheless had come to believe that mathematics is important. Faith in the practical value of mathematics persisted across informants, from the youngest (7-year-olds) to the oldest (14-year-olds). And support for their judgment about the value of mathematics seems to have been based in adult authority: None of the students had sufficient understanding either of what mathematics involves or of what skills are required by different careers to enable him or her independently to reach an informed conclusion.

The Nature and Quality of Mathematics Instruction

Although they provided neither explicit criticism nor explicit praise of the types of mathematics instruction they were receiving, the children's comments offered insights into the practices that constituted mathematics instruction in regular classrooms as well as in the gifted program. Almost without exception, the children commented approvingly about two features that differentiated their experiences of mathematics instruction in these two settings. First, they noted that the math they encountered in the gifted program was more challenging than the math presented in their regular classrooms. And second, they reported enjoying the opportunity in the gifted program to make more extensive and meaningful use of computers in learning math.

With regard to the level of the math lessons in the two settings, one third grader commented, "We're doing division over here and down there we're still on the times tables." Another shared a similar perspective: "I like to do stuff like I get to do here ... division and stuff. In school all you get to do is two plus two, three times three, zero times zero." According to a 13-year old, "most times I understand the stuff at school and I can just do it without asking any questions, but here I actually get challenged and learn something new." And another of the older students commented, "we do polynomials and stuff in here just for fun." One second-grader saw the level of challenge in the gifted program as an incentive for working harder: "You feel like doing it 'cause it's harder, and you'd rather do that as to do those other ones fast."

The children's comments suggested that the gifted program offered a more challenging experience through two sorts of practices. First, and most often mentioned, were practices related to instructional pace, accomplished by modest amounts of

curriculum acceleration and considerable flexibility in the length of time that students were required to spend in completing assignments. Students were offered work that was approximately one year ahead of the work provided in their regular classrooms, and the teacher of the gifted allowed them to move through lessons as quickly as they could and then proceed to new lessons.

Second, though far less frequently mentioned, were pedagogical practices used to elicit problem-solving. Although students' comments about these practices were limited, they pointed to the fact that there were more problem-solving activities in the gifted program than in the regular classrooms. As one child put it, "Here it is more thinking and you've got to think about the problem." Another commented: "We solve some of the stuff out loud and we do thinking problems."

Computer-mediated instruction also differed between the gifted and the regular classrooms. Whereas the regular teachers seemed to use computers to reward students for completing their work and to keep them occupied while others finished their assignments, the teacher of the gifted provided students with opportunities to make use of software that encouraged new learning and strengthened problem-solving skills. All of the teachers – both in the regular and the gifted classrooms – also appeared to be using computer programs to give students practice with skills they had already learned, such as math facts and simple computation.

Although they clearly could distinguish between more and less challenging computer applications, the students seemed to prefer even the simplest computer programs to the routine of instruction in their regular classrooms. In fact, their portraits of mathematics instruction in regular classrooms revealed practices that seemed to have

limited potential for engaging the minds of any students, let alone those most talented in mathematics.

In responding to questions that elicited descriptions of what math lessons were like, students predominantly offered the following types of answers:

Second grader: I mean, we hardly get our work done when she gets with that overhead. And she has to show kids ... we've been over it a hundred times, the same ole thing, same ole thing, same ole thing. And now she's decided for the ones who do get their math done and good grades, they're gonna be able to have free computer time. And while she's showing them other ones who will not pay attention, she'll show them, she will show them again what to do and then when we'll start a new thing we'll have to get off [the computer] and do our work.

Third grader: She just tells us to go to our math book and she tells us to go to what page and what to do and then she just like lets us do it – tells us what page and what we need to do. Sometimes we copy it off the board and sometimes we write [it] out of our math books and sometimes we do it on just plain paper.

Sometimes, if the girls or boys get a hundred ... there's four computers and she lets us go and do those computers and we have to do times tables on them. [While we're doing math,] she grades papers. She grades our social studies and stuff while we're doing it 'cause we have a lot of tests.

Third grader: She'll tell the kids how long you have to do the math, how many problems you do, and sometimes she tells ya to do all the even numbers or all the

odd numbers in the problem. And you only have a certain amount of time to do it, “so try hard.”

Seventh grader: When the bell rings you have to practice for Stanford-nine test. He’ll give us two questions out of the practice book and gives us time to answer them. Then we go over the answers and then like after we get done with that we go on with our regular lesson like Buyer Beware about ratios and proportions and percents.

Eighth grader: Our teacher, she like doesn’t talk to us. She like talks to the wall. And she sits on a podium and writes it down on a projector, and it goes back on the board and you can barely read it... What she would do is, we all have assigned seats, and she would turn the projector on [and] go over the homework we did. She’d go over that and then the last part of class like 15 or 20 minutes she’d give us our assignment.

Eighth grader: Well, when we first go she tells us to get our homework from the previous night and she checks it and she writes down a 20, I believe. And that adds up our homework grade for every week. And then she checks the homework. And then she reads the little messages before the assignment. And then we usually end up taking the assignment home every night.

Although the norm for these math classrooms seemed to involve a steady diet of routine – lecture, recitation, and practice – there were a few reports from students of other approaches. One teacher, for example, encouraged enjoyment of mathematics by treating math lessons in a positive and playful way. The two students from her class both quoted her daily invocation: “Get out your beautiful, gorgeous blue math book.” In another classroom, the teacher often put students in groups and allowed them to provide one another with help. In one of the primary classrooms, the teacher occasionally provided the children with “counters.” In several other primary rooms, teachers used competitive games to help students learn their math “facts.” Some teachers permitted students to use calculators to check their work. One primary teacher allowed students to develop graphs of their shoe sizes by putting their shoes on a large piece of paper. An eighth grader had had the opportunity in the previous year to use “algeblocks.”

Most startling, however, was that, even when prompted, students could rarely recall any specific problem-solving activities or experiential learning activities involving math. Their response to questions about such activities typically was to talk about experiences in other subjects, like science and social studies.

Overall, then, these data suggest that the gifted children in this rural district were experiencing mathematics instruction, even in the gifted classroom, that was below the level at which they might be able to perform. Moreover, this instruction represented math predominantly as calculation and rule-following and only sometimes as problem-solving and sense-making. Unlike the largest portion of their other instruction in mathematics, the children were enjoying the time they spent using computers. Most of that time, however,

was devoted to recreation (i.e., when the computer was used as a reward for rapid completion of assigned work) or to drill and practice.

Support from Home

The talented children who were interviewed all seemed aware that they had aptitude for mathematics. Most reported that, from the age of five or six, they had enjoyed math and had known they were good at it. When asked who supported them in their mathematics learning, all of the students said that they received some support from home.

Interestingly, the support they received came primarily from their mothers. One eighth-grader's comments provide an illustration: "[My mom] tries to help me when I'm having problems with math. She would help me figure out a problem if I was in trouble with it. She'd do anything to try and help me." According to another eighth-grader, "after I do my homework at night [my mom] checks it and goes over it with me and makes sure I do everything right. And she gets my math book and reviews everything with me." A second-grader reported, "Well, usually after I come home from kindergarten my mom would sit down with me and give me some math problems, and she still does."

In a few families both parents played a role in providing encouragement and assistance:

They just keep encouraging me to study my math and try to like it if I get bored with doing the stuff that we're doing in school just trying to find other stuff to do that's related to math. They always encourage me to come to gifted because I know they know I get like algebra like high school work here. (13-year-old)

And in one family, the father played the major role in encouraging his 10-year-old daughter's interest in math and in helping her with homework:

He uses math to help us with our homework 'cause when he went to college he can remember most of those things that he did, and he helps us. And we're doing better at our homework if he checks it and explains to us what we're doing wrong.

In many families, support for the learning of math was coupled with the expectation that the children would perform well in school. In two cases, children reported that this expectation was explicitly related to grades: "Mom's mad when I get like below like a B.... They just make sure I have good grades and if they don't, Mom went down to the school. Last year I didn't. I had bad grades" (13-year-old). "When I was in first grade last year, when I kept getting good grades on my report card and my dad would pay me" (7-year-old). In one family, the mother believed that, given the child's aptitude for mathematics, his standardized test score was too low: "On my SAT test last year I got like a 60 in math my mom said. She looked over it and showed the teacher ... the grades and stuff. I got a 60. She thought I did bad, but they said anything over 50 is great" (7-year-old). Many children, by contrast, explained their parents' expectations in less specific terms, such as, "They tell me that if I keep doing it, doing math how I do it now, I'll be real good at it when I get older" (10-year-old), or "my parents want me to be able to do good 'cause they know I can. They know [even] if I just don't want to do it ... I should be able to do it. But they know I can succeed at it" (10-year-old).

In general, the data suggested that parents were highly supportive of their children's efforts to learn math. Mothers seemed to play a more active role than fathers in

translating encouragement into routine practices, such as providing assistance, checking homework, and providing extra math problems for their children to solve. From the children's reports of their discussions of math at home, there was little evidence suggesting that parents saw math in ways that differed substantially from the ways teachers presented math. Like teachers, parents seemed to construe math primarily as memorized rules, calculation, and routine procedures.

Summary

The five themes represented in our data revealed that mathematically talented children in one rural district felt supported and encouraged in their study of math, with parents and the teacher of the gifted providing the greatest amount of support. These themes also suggested, however, that, even from supportive adults, the children had received neither (1) a sophisticated understanding of what mathematics considers and enables nor (2) a realistic understanding of the role mathematics plays in various professions. Moreover, although the children reported that mathematics was important in daily life, not even the older children provided examples of how mathematics beyond simple calculation was used in any practical domain. Finally, the reports of typical instructional practices in regular classrooms provided evidence that these talented children were primarily receiving slow-paced and repetitive instruction that emphasized calculation, rote memory, and rule-following. The children seemed to be encountering very little in their school experience that might cultivate their capacity for problem-solving, logical reasoning, or creative thinking.

Discussion

Our analysis of data from interviews with 16 talented mathematics students provided tentative answers to the original questions guiding the study. And these answers tended to confirm findings from previous research focusing on students' and teachers' beliefs about mathematics – both the earlier studies, which typically did not attend to context (e.g., Thompson, 1984), and some more recent studies (e.g., McSheffrey, 1992; White & Frid, 1995), which addressed context by situating students' and teachers' ideas about mathematics within a wider interpretation of their experiences at home, in the community, and at school.

Corresponding to results from research on students' beliefs about mathematics, our findings showed that the gifted children in our study harbor constrained views about what mathematics is. Like the children and adolescents studied by Frank (1998), Mtetwa and Garafalo (1989), Rector (1993), and Schoenfeld (1985), among others, our young informants saw mathematics primarily as consisting of computation, application of memorized rules, and use of prescribed procedures. These beliefs tended to dampen the children's curiosity about mathematics while at the same time encouraging them to construe their own competence in terms, on the one hand, of competitiveness and, on the other, of rigorous compliance with teachers' and parents' expectations.

Such characterizations of competence, however, may bolster an erroneous view of mathematics, namely that it represents a body of received wisdom, whose very nature limits creativity and critique. The association between success with mathematics and competitiveness may fuel elitist views of mathematics performance as a legitimate mechanism for sorting individuals into differentially valued career tracks (White & Frid,

1995). Gifted students certainly do not benefit, however, from school practices that function to link determinations of inherent abilities to status rankings in society at large (Howley, 1986).

Also possibly contributing to the development of elitist perspectives were the children's unrealistic opinions about the practical value of mathematics (see also Schoenfeld, 1985; White & Frid, 1995). By drawing on a valorized view of mathematics as widely useful (in ineffable ways) for success in college and careers, the children seemed to conclude that the material benefits made accessible through acquisition of mathematics knowledge were more significant than the types of reasoning enabled through the study of mathematics. Nevertheless, the children in our study, probably owing to their upbringing in an impoverished rural community, maintained humble views about what such success entailed. Relatively speaking, therefore, their acquisitiveness, mediated by the experience of life in the coalfields of Appalachia, was modest. Although their limited view of entitlement seemed to play no role in encouraging the children to value mathematics for its own sake, it did keep them from aggrandizing the stature associated with mathematics talent (cf. Walkerdine, 1988; White & Frid, 1995).

As well as confirming findings from earlier studies of beliefs about mathematics, our study revealed some original insights about how children experience mathematics learning in context. First, within schools, gifted students (just as those with special difficulties) seem to receive mathematics instruction from several different teachers. In our study, there was no evidence of effort among the educators involved to coordinate the instruction provided to the children in the regular and gifted classrooms. Nevertheless, the children appeared to have little difficulty negotiating mathematics practice across

settings. Although they were less fond of the approaches used in the regular classroom, they seem to have adapted to them. When given greater latitude in the gifted classroom, they adjusted to those conditions equally well.

Second, the students' mathematics experiences at home were typically tied to school mathematics. Few children reported engagement with activities at home or in the community that made use of mathematics. Family discussion, therefore, appeared to focus almost exclusively on the math that the children were learning in the classroom or the homework they were assigned. Although the students may have participated in activities that made use of mathematics informally, the children did not see these experiences as falling within the domain they had come to call "mathematics" (Walkerdine, 1988).

Nevertheless, the children's comments revealed that their parents (and sometimes other members of their extended families) definitely provided relevant and consistent support for their learning of school mathematics. The children saw family members as capable of helping them negotiate the processes involved in acquiring formal math knowledge. These primarily working-class Appalachian families seemed to play an active role in cultivating the children's participation in the mathematics curriculum that the professional educators defined.

Considering the constrained view of mathematics embedded in the school curriculum and the fact that families tended to accept the educators' construction of what mathematics involves, the children seem to have had few opportunities to see how mathematics contributes in a broad sense to problem-solving in the lifeworld. Not only did they lack experiences enabling them to see how mathematics is used in practical ways

by community members, they also seemed to have few experiences providing them with insight into the connection between quantitative thinking and dilemmas arising from life in a rural locale. As Kloosterman, Raymond, and Emenaker (1996) note in their analysis of longitudinal data on children's beliefs about mathematics,

Even if the sense of usefulness of mathematics that students are getting is enough to keep them enrolled in mathematics, it does not seem to be enough for them to appreciate many of the real-world connections of mathematics advocated by national groups (e.g., National Council of Teachers of Mathematics). (p. 53)

We suspect that the experiences of our informants resemble the circumstances that these researchers describe. Although the children seemed to recognize that the study of mathematics would play a major role in their future schooling, they could not really imagine math as an important source of meaning in their lives.

Limitations and the Basis for Future Research

Considering the small size of the sample and the reliance on interview data alone, our conclusions need to be viewed as speculative. Furthermore, we are not sure that our findings disclose anything that might properly be seen as reflecting a distinctly rural experience. Because we lack comparison groups and large sample sizes, we have no basis to determine if the experiences of mathematics reported by our informants are characteristic of rural schooling in particular or dominate schooling more generally, regardless of locale. Previous research about the beliefs of teachers and students suggests, however, that a diminished version of mathematics may be purveyed widely in US schools.

Moreover, despite questions intended to elicit connections between children's experiences in rural communities and their experiences with mathematics, our data provided little evidence of such a connection. As we suggest above, one conclusion may be that these children had limited exposure to uses of mathematics by adults in their families and communities. Another possible explanation relates to the way we designed the research. Perhaps by conducting interviews in a school building, we predisposed children to think about mathematics primarily in terms of school practice rather than in terms of practice in the lifeworld.

Our difficulties in capturing the rural experience of mathematics and mathematics learning may be instructive to researchers who wish to build on this line of inquiry. The discussion below elaborates some ideas for future research relating to rural students' mathematical experiences.

First, there is certainly room for larger-scale studies of children's experiences of mathematics, permitting analysis across demographic categories, such as locale, community SES, and culture. Research questions illustrating this domain include:

- How does the experience of school mathematics differ among students in urban, suburban, and rural schools?
- Are there systematic differences in rural children's experience of school mathematics in communities with different socioeconomic profiles?
- Among rural students, how does mathematics ability influence the experience of school mathematics (e.g., the nature and quality of mathematics instruction, home support for learning school mathematics, access to learning opportunities, and so on)?

Another fertile line of inquiry might take up anthropological questions of the sort addressed by researchers of ethnomathematics. So far, this research has focused on situated mathematics practice among economically enterprising children in countries such as Brazil (e.g., Nunes & Bryant, 1996; Saxe, 1988) and Nigeria (e.g., Oloko, 1993), and it has explored the mathematical bases for cultural production among indigenous peoples in various countries. But the approach has not yet been applied to studies of the mathematics practice of US children in the rural lifeworld (Eglash, 2003). Questions such as the following illustrate the way anthropological methods might augment understanding of the mathematics experiences of rural students:

- How does apprenticeship on family farms promote quantitative understanding among rural adolescents?
- How do sex-role expectations in Appalachia circumscribe the domains of mathematics practice typically available to children and adolescents?
- How do measurement activities that children experience on farms resonate with and differ from measurement activities included in their school mathematics curricula?

Recent sociological theory relating to identity formation might also provide a foundation for studying the mathematics experiences of rural students. For example, researchers might examine the ways that mathematics practice and the practice of mathematics education help to shape students' identities – those resonating with cultural and community expectations and those frustrating or challenging them. Research questions along these lines include:

- How does mathematics education assist in the production of the “college-going student” in rural communities and what meanings are attached to this identity?
- How do advanced mathematics students in rural communities formulate aspirations in face of the conflicting expectations of parents and educators?

Finally, research that positions the mathematical experiences of rural children and other community members within the larger, but mostly unexplored domain, of “working-class” mathematics might also be fruitful. Studies of how experiences with mathematics contribute to (and undermine) competence among working people would promote understanding the connection between mathematics knowledge and social relations of production. Some research questions elaborating this domain include:

- How do rural adults who seek post-secondary education view their mathematics course work?
- How does mathematics “expertise” influence social relations among migrant farm workers?

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