Creating Contexts for Involvement in Mathematics

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Students' (21 girls, 21 boys) self-reports of involvement in mathematics were related to instructional strategies observed in their upper-elementary classrooms. Students in high involvement classrooms reported challenges and skills as above average and matched, whereas students in low involvement classrooms reported skills as exceeding challenges. Students in high involvement classrooms also reported significantly more positive affect. Discourse analyses of instruction in high involvement classrooms revealed that teachers scaffolded instruction (i.e., negotiated understanding, transferred responsibility, and fostered intrinsic motivation). Instruction in low involvement classrooms was characterized by Initiation-Response-Evaluation sequences, emphasis on procedures, and extrinsic motivation strategies. Results imply that involvement can be socially constructed through whole class instruction and that researchers should give more attention to measuring and understanding situated motivation.

Involvement is a complex interaction of student cognition, motivation, and affect. Students who are involved in learning describe it as a time of focused concentration, attention, and deep comprehension (Reed & Schallert, 1993), as well as positive affect, goal clarity, and intrinsic motivation (Csikszentmihalyi, Rathunde, & Whalen, 1993). Most studies of involvement have focused on the individual psychological experience (e.g., Csikszentmihalyi & Csikszentmihalyi, 1988; Csikszentmihalyi, et al., 1993; Rathunde, 1993; Reed, Hagen, Wicker, & Schallert, 1996; Reed & Schallert, 1993). However, because much of students' learning takes place in classrooms, it is equally important to understand if and how teachers create conditions of involvement in whole-class settings. Mathematics classes in particular have been criticized for failing to motivate students (e.g., National Council of Teachers of Mathematics, 1989; Carr, 1996). Knowing which conditions garner student motivation would help us understand what distinguishes an involving activity from one that is boring or frustrating, as well as which specific practices of mathematics instruction promote or discourage involvement. Our first goal in this study was to describe upper elementary students’ reports of involvement in their mathematics instruction and the instructional practices observed in high- and low-involvement classrooms. Our second goal was to extend traditional laboratory and survey studies of motivation by studying actual classroom processes and their relation to motivation, thus integrating theories of motivation with methods of instruction in mathematics.

The Psychological Experience of Involvement

Recent studies of students' cognition, motivation, and affect during learning have focused on cognitive engagement, interest, and involvement. Although authors often use the terms interchangeably, the empirical research on these constructs differs in focus. Cognitive engagement describes students' reported use of metacognitive and self-regulatory strategies (Blumenfeld, Puro, & Mergendoller, 1992; Greene & Miller, 1996; Lee & Anderson, 1993; Meece, Blumenfeld, & Hoyle, 1988; Miller, Greene, Montalvo, Ravindran, & Nichols, 1996). Skinner and Belmont (1993) investigated “motivational engagement” or the “intensity and emotional quality of children's involvement in initiating and carrying out learning activities” (p. 2). Guthrie and Wigfield (1997) described four components of reading engagement: cognitive strategies, motivational goals, social disposition, and social interaction (p. 1). A common thread in these investigations is a “set of activity-related processes” (Schallert & Reed, 1997, p. 69) requiring effort and persistence.

The study of interest provides another approach to studying students' motivation, cognition, and affect during
learning. Individual interest is defined as a “disposition associated with increased knowledge, positive emotions, and increased reference value” (Krapp, Hidi, & Renninger, 1992, p. 6) reflecting a “relatively long-term orientation... toward a type of object, an activity, or an area of knowledge” (H. Schiefele et al., 1983, cited in U. Schiefele, 1991). U. Schiefele (1991) identified two components of interest, feeling-related and value-related valences. Feeling-related valences refer to feelings of enjoyment and involvement associated with a topic, whereas value-related valences refer to the personal significance of a topic. Individuals may emphasize one or the other or both valences depending on the topic and situation. Actualized interest describes wanting to learn about something for intrinsic reasons (Schiefele, 1991).

In contrast to individual interest, situational interest is acquired by participating in a context (Mitchell, 1993). Situational interest can be sparked by stimulation (i.e., “catches”), or longer term empowerment (i.e., “holds”). Mitchell (1993) proposes two facets of empowerment: meaningful content-related activities and involvement. Meaningfulness is defined as fitting content into the larger cultural context, whereas involvement refers to a process in which students are actively participating in the learning of new material, similar to a constructivist perspective (National Council of Teachers of Mathematics, 1989) and to cognitive engagement.

In this study, we have focused on students’ involvement in learning mathematics. Involvement is a psychological state that is concerned with the quality of experience during learning. Involvement differs from engagement in that the focus is not on volition and activity, such as use of learning strategies. We assume, with Schallert and Reed (1997), that cognitive engagement is usually prerequisite to involvement but that it is not sufficient to cause it. Involvement differs from individual interest in that it does not assume a long term (or preexisting) positive association with the topic, although that could be true. Involvement may come closest to Mitchell’s (1993) construct of situational interest, because it attempts to describe a momentary or situationally dependent quality of experience that participants seek to repeat. However, it differs from Mitchell’s construct in that it describes a quality of experience that is more related to cognitive activity as opposed to “doing things” (Mitchell, 1993, p. 428).

During involvement, attention is wholly concentrated, time passes quickly, and there is deep comprehension, focused emotional investment, and a motivational drive to continue (Schallert & Reed, 1997). Involvement is frequently used to describe the psychological experience arising from intrinsic motivation or doing an activity for its own sake (Deci & Ryan, 1985). The central focus of our investigation was to describe the quality of students’ experiences during mathematics lessons as they related to patterns of mathematics instruction.

Research on Involvement

Reed and Schallert (1993) developed an empirical definition of involvement in academic discourse. They asked college students to rate their involvement in activities such as reading and writing for course assignments. Results revealed two major components of involvement. First, students reported deep concentration. Three characteristics facilitated concentration, including focused attention, moderate task difficulty, and importance of the task to the student. The second component of involvement was an increased understanding of the task and of the students’ goals for the task.

Csikszentmihalyi’s research is closely related to the study of involvement. His research program has been devoted to developing a theoretical model of intrinsic motivation and to a description of the quality of “optimal experiences” that he has called flow (Csikszentmihalyi & Csikszentmihalyi, 1988; Csikszentmihalyi & Nakamura, 1989; Csikszentmihalyi, Rathunde, & Whalen, 1993). Flow describes a state of mind that results from being involved in an activity that is chosen for its own sake and that promotes personal growth through challenges of existing abilities. It is assumed to be a relatively infrequent experience, related to both personal and situational factors.

The definition of flow was developed through interviews with people who appeared to participate in activities for no reward other than the experience itself (Csikszentmihalyi, 1975). This definition has much in common with the one developed by Reed and Schallert (1993). Interviewees said that during flow experiences, they formulated clear goals based on feedback about their progress, focused exclusive attention on the activity, increased concentration, felt a sense of timelessness and a loss of self-consciousness, and experienced a balance between the challenges of the activity and their ability to meet them.

This last characteristic, the balance between challenges and skills, was one of the most widely mentioned aspects of flow, regardless of gender, race, age, or occupation (Csikszentmihalyi, 1985); therefore, Csikszentmihalyi and his colleagues selected it as the best indicator of intrinsic motivation or involvement. According to this theory, when people exercised challenges and skills that were both balanced and above average, they would feel most positive about the experience because they were functioning at their fullest capacity.

To validate this indicator, Csikszentmihalyi and his colleagues (1988) developed the Experience Sampling Form (ESF), which contained numerical scales measuring affect, potency, self-esteem, cognitive efficiency, degree of engagement, and intrinsic motivation. Rather than define flow as any of these qualities, the researchers looked for an empirical correlation between the balance of above-average challenges and skills on the one hand, and positive experience on the other. Because the two sets of variables were conceptually distinct, this expectation could be falsified by the data (Csikszentmihalyi & Csikszentmihalyi, 1988). Therefore, on each ESF form, in addition to the scales of positive states of consciousness, there were two items: “What were the challenges in this activity?” and “What were your skills in this activity?”

Various ratios of challenges and skills are predicted to lead to different qualities of experience (cf. Csikszentmi-
halyi & Nakamura, 1989). If challenges and skills are both high, one feels involved. If both challenges and skill are low, one feels apathetic. If challenges exceed skills, then one feels anxiety, whereas if skills exceed challenges, then boredom is experienced. The theoretical model has been substantially supported (e.g., Carli, Delle Fave, & Massimini, 1988; Csikszentmihalyi, Rathunde, & Whalen, 1993; Massimini & Carli, 1988), with reports of flow correlated with positive psychological states.

The research of Csikszentmihalyi (1975) and of Reed and Schallert (1993) have been focused on adolescents and adults and on their individual involvement experiences. In this study, we attempted to extend involvement research to elementary school-age children and to experiences during whole-class mathematics instruction. We asked, “What combination of challenges and skills can be accommodated in a schoolroom... [in order to] maximize flow engagement for as many people as possible?” (Csikszentmihalyi, 1975, p. 203). In the next section, we proposed a schema for analyzing the “involvement potential” of classroom instruction.

Involving Instruction

In their study of the academic experiences of talented teenagers, Csikszentmihalyi, Rathunde, and Whalen (1993) asked students to describe what teachers did to involve them in their classes. The students reported that teachers used a variety of strategies that fostered learning while supporting motivation. First, these teachers demonstrated a keen “sense of timing and pace, and understanding of when to intervene and when to hold back” (pp. 187–188). They knew when to provide support and when to demand autonomy, when to backtrack and when to raise the challenges anew. Second, these teachers showed enthusiasm for subjects that seemed boring in other teachers’ classes. They demonstrated their personal intrinsic motivation and they downplayed extrinsic pressures like completion, grades, and procedural rules. Third, they knew how to use mistakes as occasions for learning and improvement. They provided feedback rather than evaluation.

Such descriptions suggest multiple instructional strategies that teachers can use to support and sustain involvement. One commonality among these descriptions is that teachers who evoked high involvement appeared to scaffold instruction. Scaffolding, or “assisting instruction” (Gallimore & Tharp, 1990), may foster involvement because it supports and remains involved in “learning for learning’s sake.” In scaffolding, the teacher’s sensitivity to and support of students’ needs is two-pronged: to provide guidance for accomplishing the learning goal only as necessary and to move from a position of shared responsibility to one in which the student takes control of learning goals and processes (Hogan & Pressley, 1997; Langer, 1984; Palincsar, 1986; Palincsar & Brown, 1984; Rogoff, 1990; Wood, Bruner, & Ross, 1976). It is important to note that teacher support is not only cognitive but also motivational and affective. For example, teachers support students through initiating and sustaining their interest and mediating frustration (e.g., Wood, Bruner, & Ross, 1976). Therefore, from syntheses of the theoretical definitions and empirical characteristics of instructional scaffolding (Meyer, 1993), we gleaned three important ways in which teachers involve students in learning during scaffolding: negotiating meaningful learning, promoting student control of thought and actions through transfer of responsibility, and providing intrinsic supports for learning.

Negotiating Meaningful Learning

During instructional scaffolding, the teacher supports students’ understanding while students build higher level competencies. For example, teachers adjust instruction to meet students at their current level of competencies and help them build meaning. These instructional strategies focus students’ attention, foster greater concentration, provide feedback about goals, and keep the task at a moderate level of difficulty. Through negotiation, instruction sustains the learning activity at a level where students’ skills, with the teacher’s assistance, can meet challenges and students can build new understanding. The following excerpts of teacher discourse provide some examples:

“Percent is per 100. Yes, I agree. And therefore. . .”

“Look at the chart we just created. It should be no surprise how we went from fraction to decimal and back to fraction, right?”

“Where did they get the 17%? That is a very good question. Where did they get that what do you think?”

“Oh, now Lu said we’re doubling each square, right? Can somebody else explain that using different words? We’re doubling each square. What else are we doing?”

“I want to make sure everyone understands what you did.”

Transferring Responsibility for Learning

When teachers scaffold instruction, they also guide students in developing strategies for taking control of their learning and provide opportunities for student autonomy. In scaffolding, teachers move from a position of sharing responsibility for learning with students to one in which they transfer responsibility to students. Through transfer, teachers require their students to develop and demonstrate strategies and understanding. Ways in which teachers guide students toward autonomous learning are by exploring possible strategies with students, asking them to evaluate their strategies and thinking, and to demonstrate their understand-
ing. The following teacher responses illustrate transfer of responsibility in discourse:

““How did you figure that out?”
“Now look at 13/86 and I want you to do the same thing.”
“Now if I got rid of these zeros, I get 1/4 th. That might be an approach to get an educated guess. Anyone else?”
“Your technique is very correct, but I want to know why?”
“What if I had only given you 37 [and] 1/2 percent? Could you go backwards? Here is the answer, we know what it is. How could we go backwards?”
“We’re going to play a game today and see if we already know that.”

Supporting Intrinsic Purposes and Tasks

Descriptions of instructional scaffolding include a variety of ways in which teachers influence students’ motivation for learning, such as how teachers balance challenge and support, evoke students’ interest and curiosity, mediate frustration, provide encouragement, advocate risk taking, respond to errors, and comment on progress. Teachers’ explicit and implicit lessons about the values, expectations, and emotions related to learning goals are powerful intrinsic motivational supports for students. Teachers can create a climate for involvement through maintaining interest in and a commitment to learning and establishing positive affect for approaching challenges (Csikszentmihalyi, Rathunde & Whalen, 1993). Such support for students’ efforts to learn is found throughout discussions of teacher scaffolding. For example:

““That’s not going to work right there, but you’re on the right track.”
““Last one, kind of tricky.”
““What gives you the right to move the decimal point two spaces? What are you? King of the decimal point?”
““I don’t want to say difficult, but challenging for us.”
““You have to be confident. I know that’s kind of confusing and tough and I don’t expect you to get that just like that...”
““What’s a practical application of knowing this? When could you use it in real life?”
““Let’s move on to the percents and fractions. Those are kinda cool.”

Nonscaffolding Forms of Teacher Discourse

In traditional mathematics instruction, it is common for the teacher to present a mathematical “problem” along with an algorithm for solving it and then to assign similar problems for students to practice (Lampert, 1990; Stein, Grover, & Henningsen, 1996; Stodolsky, 1988). In this type of setting, discourse is often characterized either by teacher “telling” or by the asking and evaluation of “right answer” questions, tasks that require memorization of facts or algorithms. Thus teacher–student interaction can be limited by teacher control of what counts as mathematical knowledge (e.g., Mehan’s “known-answer question,” 1985).

From the perspective of involvement, such instruction would be less likely to present ideas in a challenging way and the processes required would foster repetition rather than the development of new skills (Doyle, 1983). Whereas student skills might be high, challenges would be low, resulting in more boredom and less involvement. Furthermore, such approaches would be less likely to support the growth of student competencies. “Ownership” of mathematical knowledge would remain with the teacher or the textbook rather than be developed within the student. Under such highly controlled discourse structures, teachers typically motivate students through extrinsic rewards and praise or with threats for noncompliance. These instructional strategies provide limited support for intrinsic motives such as growth of student competence and autonomy. Therefore, discourse practices such as Initiation-Response-Evaluation (I-R-E) sequences, teacher procedural statements about thinking or actions, and extrinsic supports for learning, would be predicted to be associated with lower involvement contexts.

Involvement in Mathematics Classrooms

We elected to study involvement in mathematics classrooms because mathematics education has come under considerable scrutiny concerning both cognitive and affective outcomes. Math instruction has been criticized as boring and frustrating so that “motivation for mathematics may suffer appreciably in all but those few students devoted to the subject” (Stanley and Benbow, 1986, p. 368) and as “severed from the real world... consisting! of meaningless bits and pieces” (Davis, 1992, p. 730). More pointedly, Lampert (1990) contends that in school, “doing mathematics means following the rules laid down by the teacher, knowing mathematics means remembering and applying the correct rule when the teacher asks a question, and mathematical truth is determined when the answer is ratified by the teacher” (p. 32). Accordingly, we hypothesized that the culture of mathematics classes might place a premium on teacher control and performing well, thus encouraging students to adopt a self- rather than a task-focus (Carr, 1996; Prawat & Anderson, 1994). This emphasis would be less likely to foster a climate for intrinsic motivation and involvement.

Negative affect is common in mathematics classrooms, where students often report confusion and concern with completion and accuracy (Prawat & Anderson, 1994). These negative qualities of math instruction are presumed to influence students’ quality of experience in mathematics and, later on, their choice of mathematics courses and mathematics-related careers. As a result, reform documents (e.g., National Council of Teachers of Mathematics, 1989) have emphasized the importance of promoting positive attitudes and interest in conjunction with developing understanding in mathematics. Therefore, understanding how teachers create positive climates for learning and motivation in mathematics has considerable pedagogical importance as well as implications for students’ mathematical involvement.

We hypothesized that involving mathematics instruction
would include both the opportunities for students to meet challenging goals and the necessary cognitive, motivational, and emotional supports to help students attain these goals. Assuming that involving instruction must represent a merging of teachers' instructional strategies for and students' perceptions of involvement, our research questions were:

1. What is the quality of experience for students in fifth- and sixth-grade mathematics classrooms?
   a. Do students report being involved in mathematics classes through high ratings of challenge and skill that are matched?
   b. Do students' ratings of challenge and skill correspond to important concomitants of involvement: affect (cooperative, happy, part of the group, pride), cognition (alert, clear, excited, mentally strong, relaxed) and motivation (involved, wanting to learn)?
2. How are students' qualities of experiences in mathematics classrooms related to characteristics of instruction found in teacher whole-class discourse patterns?

Method

Data Collection

Participants

The participants in the study were 42 students and their fifth- and sixth-grade teachers. Students were in seven classrooms in three elementary schools in a small, mostly White, middle-class town in rural Pennsylvania. There were two high-ability classes, two average-ability groups, two low-ability classes, and one heterogeneous group. The California Achievement Test (CAT) total battery Normal Curve Equivalent scores were 83.9 and 93.8 for the high-ability classes, 87.5 and 79.3 for the average-ability classes, 59.0 and 60.8 for the low-ability classes, and 71.4 for the heterogeneous class. Therefore, four of the classes were above average and two were average-ability classes by national norms. Because CAT data were collected after the completion of the study and required parental consent, NCE scores represented 64–80% of the student population across classes. Six of the 7 teachers who participated were women. Their experience ranged from 1 to 22 years.

We randomly selected 6 student participants by gender from each class from those who returned permission slips, yielding 21 girls and 21 boys. We selected only 6 participants to minimize the disruption of data collection during the transition at the end of math class and to place importance on the information the students provided. In a pilot study, we had discovered that students frequently compared responses during completion and we wanted to emphasize individual reports.

Measures of Classroom Instruction

We audiotaped the classroom discourse during regular mathematics instruction for a period of 4 to 5 days during the spring of 1995 and then transcribed each lesson. In addition, we used a classroom observation instrument to provide additional information. The observations provided descriptions of instructional activities that could not be deduced from audiotaped recordings. For example, observers recorded all work from the board, teachers' and students' demeanor, whether students were working in small groups, or how students moved about the room.

Student Measures

The 42 student informants filled out a response log on the days we observed instruction. These individual logs of students' perceptions of instruction were adapted from the ESF described by Csikszentmihalyi and Larson (1987). During pilot testing, students responded to 13 semantic differential scales that forced choices between opposing feelings such as happy–sad and open–closed. If students were unclear about the meaning of certain words, experimenters described the intended meaning and asked students to suggest a synonym. “Alert–drowsy” was changed to “alert–sleepy,” “cheerful–angry” was changed to “cheerful–crabby,” and “relaxed–tense” was changed to “relaxed–upright.” Items that were not changed were happy–sad, bored–excited, proud–ashamed, clear–confused, weak–strong, open–closed, and cooperative–competitive. According to Csikszentmihalyi and Whalen (1993), these items represent important concomitants of intrinsic motivation.

We adapted the ESF forms thus contained the 13 semantic differential items (measured on a Likert scale from 0 [low] to 9 [high]) with a midpoint of neither and 1 item measuring intrinsic motivation, “Do you wish you had been doing something else?” measured on a 4-point scale (from very much to not at all; reverse scored). The theory of flow posits that the perceived ratio between challenge and skill is the primary condition for optimal experience in any activity. Therefore, students also answered two questions—“How challenging was math class today?” and “How were your skills in math today?”—by circling a number for each question on a Likert scale from 0 (low) to 9 (high) to derive a measure of the challenge–skill match.

Procedures

Each author, except Debra K. Meyer, contributed observational records for a total of 34 mathematics classes (at least four for each teacher). All audiotapes and observations were completed during an intact mathematics unit during the spring semester. Observers sat at the back of each classroom taking field notes and placed a tape recorder near where the teacher stood to record all instructional discourse.

During the last 5 min of each observation day, observers distributed the response logs (ESFs) to student informants. Although the standard use of the Experience Sampling Method (ESM) is to electronically “beep” students randomly during the day and ask that they complete an ESF describing their thoughts and feelings at that specific time, we did not want to disrupt mathematics classes by distributing student logs in the middle of activities. Therefore, we asked students to generalize about the entire class experience. Although we were aware that students' involvement might ebb and flow during class (e.g., Reed et al., 1997), there was rarely more than one class activity, and we intended to measure the overall assessment rather than involvement during any one phase.

Coding of Classroom Discourse

Discourse Categories

Based on our review of the literature and previous research, we used six a priori categories for coding the whole-class discussions during mathematics instruction. Each category represented either extensive possibilities for ways in which the teacher's response
might either scaffold and involve students in learning or attempt to restrain student participation and diminish student involvement. Three categories represented scaffolding: negotiation, transfer of responsibility, and intrinsic supports. In parallel, three categories represented nonscaffolding instructional discourse: I-R-E patterns (Mehan, 1985), teacher responses regarding procedures or routines, and extrinsic supports. These categories are described briefly in Table 1.

Coding Procedures

After practice coding a set of transcripts from earlier in the school year, the teacher response categories were established using illustrative examples. Conflicts between coders were reconciled by applying these refined characteristics and procedures for coding were established. Only teacher responses were coded, and a coded response could range from a single word to the entire speaking turn. A coded response indicated that the categorization continued until the teacher's turn ended or a different code was used. Furthermore, responses could be coded in multiple categories. Therefore, it was necessary for coders to agree not only on the type of response, but also on when categories ended or began, as well as on whether categories were discrete or co-occurred. If one coder changed categories but the other coder did not, then a "disagreement" was recorded. If one coder marked a response as two simultaneous categories and the other coder marked it as a single category, which agreed with one of the two simultaneous codes, then an "agreement" and a "disagreement" were recorded. Julianne C. Turner, who led the data collection team, categorized the teacher responses on approximately half of the transcripts for each teacher, and Debra

<table>
<thead>
<tr>
<th>Discourse category</th>
<th>Defining features</th>
<th>Examples</th>
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<tbody>
<tr>
<td>Negotiation</td>
<td>Adjusting instruction in response to students and guiding students to deeper understanding.</td>
<td>&quot;Let's break this problem into parts.&quot;</td>
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<td></td>
<td></td>
<td>&quot;What information is needed to solve this problem?&quot;</td>
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<td>Transfer of responsibility</td>
<td>Supporting the development of strategic thinking, of autonomous learning, and holding students accountable for understanding.</td>
<td>&quot;Explain the strategy you used to get that answer.&quot;</td>
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<td>&quot;You have to come up with a rule to justify your answer.&quot;</td>
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<td>Intrinsic support</td>
<td>Supporting learning goals: viewing challenge as desirable, advocating risk taking, responding positively to errors, and commenting on progress.</td>
<td>&quot;Let's see if your solution is accurate.&quot;</td>
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<td>&quot;This may seem difficult, but if you stay with it, you'll learn more than you bargained for!&quot;</td>
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<td>&quot;This is where you have to start thinking!&quot;</td>
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<td>&quot;That's great. I just love that. Do you see what he did...?&quot;</td>
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<tr>
<td>Initiation-Response-Evaluation (I-R-E)</td>
<td>The routine of asking a know- answer question or evaluating a student response as right or wrong.</td>
<td>&quot;What is the reciprocal of 34/56ths?&quot; &quot;34/56ths. Very good!&quot;</td>
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<td>Minimizing student talk through prescribed &quot;turn taking.&quot; Establishing the authority for knowledge in the teacher or text.</td>
<td>&quot;That is exactly what the book says!&quot;</td>
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<td>&quot;What is the answer to number thirteen?&quot;</td>
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<td>&quot;And they did that in the book that way.&quot;</td>
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<tr>
<td>Procedures</td>
<td>Giving directions and implementing procedures, or telling students how to act and think (i.e., treating learning as a &quot;listen and write&quot; activity).</td>
<td>&quot;Just listen and write down what I say.&quot;</td>
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<td>&quot;We all know that the reciprocal of 34/56ths is 56/34ths.&quot;</td>
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<td>&quot;Write this on your paper, it's simply memorizing the pattern.&quot;</td>
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<td>&quot;You need to pay attention.&quot;</td>
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<td>&quot;Take out your books and number your papers from 1 to 25.&quot;</td>
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<td>&quot;What neat handwriting, your papers are always a pleasure to grade!&quot;</td>
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<td>&quot;When you decide to listen, you may learn some math.&quot;</td>
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<td>&quot;I want your parents to sign this text.&quot;</td>
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<td>&quot;I was shocked by these grades.&quot;</td>
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<td>&quot;This is simple stuff.&quot;</td>
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<td>Extrinsic support</td>
<td>Using superficial responses, to encourage students to focus on positive aspects other than learning (e.g., ease of completion), or using threats or negative expectations to gain student compliance.</td>
<td>&quot;Let's break this problem into parts.&quot;</td>
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Table 1: Distinguishing Features of Discourse Categories
K. Meyer, who did not visit the classrooms, categorized teacher responses on all transcripts. Each transcript was assigned a random number to counter any potential effects from the order of coding.

Interrater Agreement

We calculated interrater agreement for each teacher using gamma (William L. Hays, personal communication, November 11, 1990). Gamma is calculated separately for each teacher by creating a table of "hits" (agreements) and "misses" (disagreements) between two coders across all transcripts for a particular teacher. Gamma is a ratio of average agreements to the sum of the average agreements and average disagreements. A gamma of 0 indicates no agreement between coders and a gamma of 1 indicates perfect agreement. Our goal was to achieve gammas of .80 for every teacher. The indices of agreement for the teachers were: Adams, .87; Benjamin, .83; Carey, .87; Duncan, .85; English, .90; Ford, .91; and Grant, .84, for an average gamma of .867. The transcripts of Duncan had to be recoded to improve an initial gamma of .78 to .90 for an average gamma of .85.

Results

Students’ Quality of Experience

Student Self-Reports of Involvement

To determine if the student informants reported optimal experiences indicative of involvement, we compared classrooms on mean student ratings of the item, “How challenging was math class today?” using analysis of variance (ANOVA) and planned comparisons. Finding a significant difference among the classrooms, F(6, 41) = 8.0584, MSE = 16.3650, p < .0001, we tested all possible pairwise comparisons using Tukey’s multiple comparison procedure to achieve maximum power while maintaining an experimentwise alpha at .05. The assumption of homogeneity of variance was met according to the Levene test. Separate variance estimates were used because we assumed that the classrooms represented unique contexts. Means and standard deviations for the challenge variable by classroom are presented in the top portion of Table 2. The comparisons revealed that the mean challenge rating in Ms. Benjamin’s classroom was significantly higher than the mean ratings in the classrooms of Ms. Duncan, Ms. English, Ms. Ford, and Ms. Grant. In addition, the mean challenge ratings in Ms. Carey’s and Ms. Adams’ classrooms were significantly higher than those in the classrooms of Ms. Ford and Ms. Duncan. Skill ratings (“How were your skills in math today?”) did not differ significantly by teacher. All teacher names are pseudonyms, and gender has been changed.

We then compared the means for the challenge and skill variables by classroom to determine the “match” between them. We found that in the classrooms of Ms. Benjamin, Ms. Carey, and Ms. Adams, the means for challenge and skill were high and closely matched. However, in the classrooms of Ms. English, Ms. Ford, Ms. Grant, and Ms. Duncan, the challenge means were lower (all in the bottom half of the range, 0–9) and the average ratings of the students’ skills exceeded the challenge means. Therefore, we concluded that student ratings of challenge and skill indicated higher involvement in the classrooms of Ms. Benjamin, Ms. Carey, and Ms. Adams.

Relation of "Quality of Experience" to High- and Low-Involvement Classrooms

Next, we asked if students in the high-involvement classrooms were more likely to report flow. We classified students into four groups based on Csikszentmihalyi’s (Csikszentmihalyi & Nakamura, 1989) criteria for quality of experience: flow (both challenge and skill > 0), boredom (challenge < 0 and skill > 0), apathy (both challenge and skill < 0), and anxiety (challenge > 0 and skill < 0). Scores were treated as situationally dependent such that multiple reports provided by the same student but on different days were considered to be independent of each other. These scores were standardized across all independent measures so that 42 students provided 181 relative experiences of challenge and skill. For this analysis, three quadrants (boredom, apathy, anxiety) were collapsed into a nonflow category.

A logistic regression was conducted to determine if student classification (flow versus nonflow) was related to classroom membership. To avoid the perfect fit generated by a saturated model, main effects were not tested. Rather, the Flow category X Teacher interaction was tested. This 2 X 7 analysis revealed a significant Teacher X Flow interaction, \( \chi^2(1, N = 182) = 10.97, p < .001 \). A series of planned pair-wise comparisons were completed to compare the flow

<table>
<thead>
<tr>
<th>Table 2</th>
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<tr>
<td></td>
<td>High-involvement classrooms</td>
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<tr>
<td></td>
<td>Adams</td>
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<td></td>
<td>M</td>
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<td>Rating</td>
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<td>Flow</td>
<td>11</td>
</tr>
<tr>
<td>Nonflow</td>
<td>21</td>
</tr>
</tbody>
</table>
The three high-involvement classrooms were also significantly more likely to rate their classroom experience as involving and intrinsically interesting.

**Patterns of Whole-Class Instructional Discourse**

In response to the second research question, the teachers' individual proportions in each of the six discourse categories were entered into a contingency table with the response categories as rows and the teachers as columns. Using this comparative table, we calculated standardized residuals to determine the interrelationships of teacher and discourse categories. Each standardized residual was computed by taking the frequency of the cell, subtracting the estimation of the expected frequency for the cell, and dividing by the square root of the expected frequency (Hays, 1988). Standardized residuals are interpreted as normal z scores. For this study, we were interested in the relative (positive and negative) relationships of the discourse categories among the teachers. Table 3 presents the standardized residuals of each category across teachers. We organized the table to present the patterns for high-involvement contexts on the left-hand side and low involvement on the right-hand side.

To illustrate how student involvement and instructional discourse differed among the more involving and less involving mathematics classes, we provide brief descriptions of instructional practices and excerpts of classroom discourse.

**Creating Contexts for Involvement: Ms. Adams, Ms. Benjamin, and Ms. Carey**

In the three classrooms rated as more involving by the students, the teachers' instructional approaches shared ratings of challenge that were high and matched with the students' reported skills levels. Two of the high-involvement teachers (Ms. Adams and Ms. Benjamin) demonstrated high frequencies across all three scaffolding categories. The third high involvement teacher, Ms. Carey, shared her use of intrinsic supports for learning mathematics and the transferring of responsibility. We illustrate their instructional approaches with brief descriptions and typical excerpts from their classes.

**Ms. Adams.** Ms. Adams has 10 years experience and taught an average-ability math class. She typically used one complex activity that could extend over several days. These activities had a conceptual focus but also required students to practice procedural skills, such as reducing fractions, in a new context. Ms. Adams presented difficult problems and was skilled at alleviating the inevitable student frustration that accompanied them. She was aware of when her students' skills might be low in relation to the difficulty of the lesson; however, instead of altering the goals of the task, she adjusted instruction until students' skills matched the challenge. In addition, she held students accountable for understanding by asking them to justify their reasoning and conclusions. She also provided intrinsic supports for their efforts through her focus on learning goals, never allowing the focus to stray from mathematics, and accepting error as a natural part of learning. The complexity of Ms. Adams's score associated with each classroom with the others. Family-wise alpha levels were controlled at .05 with the use of a Bonferroni adjustment. Frequencies are reported in the bottom half of Table 2. Results showed that students in Ms. Benjamin's class were in the flow quadrant significantly more often than students in any of the other classes. Students in Ms. Carey's class were in the flow quadrant significantly more than students in the classes of Ms. Adams, Ms. Duncan, Ms. English, Ms. Ford, and Ms. Grant, but significantly less than students in Ms. Benjamin's class. Students in Ms. Duncan's class were in the flow quadrant significantly less than students in any of the other classes. Students in the classes of Ms. Adams, Ms. English, Ms. Ford, and Ms. Grant did not differ significantly from each other in the frequency of their reports of flow. Therefore, students in two of the three high-involvement classrooms tended to report significantly more experiences of flow than students in other classrooms. Because of the high level of challenge in Ms. Adams' classroom, her students were more likely than others to report anxiety (challenges exceeded skills), whereas the students in the classrooms of Ms. English, Ms. Ford, and Ms. Grant were more likely to report apathy or boredom.

**Relation of High Challenge and Skill Match to "Quality of Experience"**

Having established that classrooms did differ on student ratings of challenge and its match with skill ratings, we then asked if high and matched ratings of challenge and skill corresponded to important concomitants of intrinsic motivation such as positive affect, enhanced cognition, and greater motivation. According to the theory of optimal experience, students in the flow cluster are more likely to report positive feelings. Data included four to six challenge and skill responses per student (N = 181). Consistent with the research of Csikszentmihalyi and colleagues (e.g., Csikszentmihalyi, Rathunde, & Whalen, 1993), we treated student responses on challenge and skill variables as situationally dependent such that multiple reports provided by the same student on different days were considered independent of each other. These responses were then standardized across students. This allowed for students in any classroom who had rated challenge and skill above the group mean of zero to be represented in the flow quadrant. Next, means on the 13 semantic differential scales (happy, clear, etc.) were computed for each cluster and then compared with the cluster mean of zero using t tests. Only the results for the flow cluster are reported (n = 78). Students who reported above-average challenges and skills also reported feeling significantly more involved, $M = .22$, $t(1, 77) = 2.36, p = .021$; open, $M = .19$, $t(1, 77) = 1.97, p = .05$; relaxed, $M = .18$, $t(1, 77) = 2.07, p = .042$; and intrinsically motivated, $M = .36$, $t(1, 77) = 2.80, p = .007$.

In sum, using the students' self-reports of the match between challenge and skill as well as their corresponding ESF reports of involvement, we concluded that higher levels of involvement were found in the classrooms of Ms. Benjamin, Ms. Carey, and Ms. Adams. Students in two of the three high-involvement classrooms were also significantly more likely to rate their classroom experience as involving and intrinsically interesting.

**Creating Contexts for Involvement**

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### Table 3

**Instructional Discourse Patterns: Standardized Residuals and Individual Percentages for Teacher × Discourse Categories**

<table>
<thead>
<tr>
<th>Discourse pattern</th>
<th>High-involvement classrooms</th>
<th>Low-involvement classrooms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adams</td>
<td>Benjamin</td>
</tr>
<tr>
<td>Adjustment</td>
<td>+</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>3.54</td>
<td>3.53</td>
</tr>
<tr>
<td></td>
<td>36%</td>
<td>38%</td>
</tr>
<tr>
<td>Transfer of responsibility</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>4.25</td>
<td>1.60</td>
</tr>
<tr>
<td></td>
<td>25%</td>
<td>18%</td>
</tr>
<tr>
<td>Intrinsic support</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>1.88</td>
<td>1.49</td>
</tr>
<tr>
<td></td>
<td>8%</td>
<td>10%</td>
</tr>
<tr>
<td>I-R-E</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Teacher procedures</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>—2.98</td>
<td>—2.72</td>
</tr>
<tr>
<td></td>
<td>9%</td>
<td>12%</td>
</tr>
<tr>
<td>Extrinsic support</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>—2.29</td>
<td>—2.10</td>
</tr>
<tr>
<td></td>
<td>0%</td>
<td>2%</td>
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</table>

**Note.** Standardized residuals and percentages reflect the presence (+) of scaffolding responses in high-involvement classroom teacher discourse and absence (−) in the discourse of low-involvement teachers. The high-involvement teacher discourse specifically shared the features of transferring responsibility and intrinsic supports, whereas these same categories were not features of any of the low-involvement teacher discourse. High-involvement teacher discourse showed an absence of nonscaffolding responses, specifically in the categories of procedures and extrinsic supports. The low-involvement teacher discourse illustrated a presence of all the nonscaffolding categories, except Ms. English, who did not respond with either extrinsic or intrinsic supports. Three percent of Ms. Adams' and 1% of Ms. Fords' discourse responses could not be represented uniquely in any one cell of the chart. I-R-E = Initiation-Response-Evaluation.

discourse was reflected in the fact that 11% of her coded responses was reflected in combinations of scaffolding categories. Ms. Adams's students rated challenges as slightly ahead of their skills.

In the following excerpt the class was beginning a 2-day lesson on generalizations about multiplying fractions. In the excerpts, T = the teacher and S = the students.

**May 2, 1995**

[At the beginning of class, Ms. Adams gave students a fraction calculation to write down: 23/31 \times 13/86.]

T: Is the answer to this equation smaller than the smallest number? Is it between the two numbers? Or is it larger than the largest number? You are not allowed to solve this with any computations! You have to come up with a rule to justify your answer that you can say that when the fraction numerator has a three in the one's digit, then the answer will always be between 0 and the smaller fraction. Now that was hypothetical of course. But that's the kind of thing you have to look at. Question? [No one responds.]

[During the students' first attempt to work the problem, the groups encounter difficulty. Teacher interrupts group work for a moment.]

T: Freeze! You can actually first figure out the answer by multiplying, but then you must come up with a generalization for me.

[After a second attempt to work in groups to the solve the problem, T calls the class back together.]

T: Now let's look at these a little differently because I think you're getting bogged down with the fact that when you multiplied these out, you got a big number. Who has the answer?

S: 2,760.

T: Now that's a really big number and when you look at it, it seems a little overwhelming. But let's take this one apart. This number 23/31 . . . Who can give me a number with a single digit on top and a single digit on the bottom that roughly equals 23/31? Roughly equivalent.

[Having modeled how to reduce and compare for the first fraction (23/31), T now turns it back to the group—can they do it for 13/86? T asks one student who is unsure so]

T: What is it roughly equal to?

[Silence for a minute.]

T: Well, someone already said one-something. You might need to start thinking in terms of that. Three-eighths anyone. Sandra, do you have a guess?

S: No.

T: Sandra, how would you approach, looking at 13/86, a single digit over a single digit. Do you have any idea?

[Sways head "no."]

T: OK, look at 13/86, what if I just dropped this, what if I just round off, what's 13 rounded to the nearest 10, Sandra?

[No response.]

T: When I round to the nearest 10th, Sandra, look at the one's if it's less than 5 . . .

Sandra: 10.

T: Yes, it's 10. Look at the 86, rounded to the nearest 10th. It becomes . . .

Sandra: 90.

T asks for more "educated guesses" for reducing the fraction 13/86. T has several guesses on the board now. When a student makes an erroneous guess, then says he "did it
Ms. Benjamin. Ms. Benjamin, a teacher with 14.5 years of experience, taught a high-ability class. She negotiated mathematical meaning by elaborating on student responses and by showcasing and explaining students' multiple solutions to problems. She encouraged students to use any method that made sense, and then she required them to justify their solutions mathematically. Rather than reserving ownership of mathematical ideas for herself, she extended the role of "mathematical expert" for herself, she extended her practice by including both the value of mathematics for its own sake and her enthusiasm for mathematics as a mode of thinking and communication.

In the following excerpt, Ms. Benjamin's class was discussing and completing three charts on the board (decimal with corresponding percent, fraction with corresponding percent, and percent with corresponding fraction). During the lesson, the teacher and students discussed how they derived their solutions.

May 9, 1995

[At the beginning of the lesson, T questioned the students about the rationale for the algorithm of moving two decimal places when converting between decimals and percents.]

T: What is the deal with that? It is real easy just to say move the decimal point two spots. What does that mean? What is the significance of two spots? Why don’t we move it 20 spots or five spots? Why does that give us a percent? Grant?

S: Four-eighths would be half... so half would be 50%... Let me write that down. 4/8 would be half, 50%... And 6/8 would be 75%.

T: OK.

S: OK. Now you got it. You were saying it backwards. So, if I move one decimal point anywhere one way or the other, what am I actually doing to that number?

T: Making the number larger or smaller.

S: The by 10... and if we go 2, then... we do...

T: One hundred.

S: One hundred. When we are talking about percent, we are talking about out of 100. So that’s where the 100 comes into play. So you have a decimal and you want to find out the percent, you really want to find out how many out of 100 so move it that way and it will give you the percentage—the number that is the percent out of 100.

T: OK. Anyone want to add to that? If I move one decimal point anywhere one way or the other, what am I actually doing to that number?

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and accountability through the whole class discussions. She frequently focused on understanding mistakes and viewing them as learning experiences, and conceptually connecting mathematics concepts. Although Ms. Carey's classroom discourse shared the qualities of transfer of responsibility and intrinsic supports for learning found in the other two involvement classrooms, her method of reporting back from small-group work provided long I-R-E sequences and organizing the small group work promoted teacher procedural talk. Therefore, the students' ratings of high and matched levels of challenge and skill may stem from Ms. Carey's high use of intrinsic supports and transfer of responsibility coupled with the autonomous learning experiences that small-group work afforded. Her discourse patterns reflected math classes organized around small group work with some whole-class discussions.

In the following excerpt, students had been given cards with a percent, fraction, or decimal on it. They were to find their "matches" with other classmates (i.e., 1/3, 33 1/3% , and .33). After this, the teacher conducted a whole-class lesson on converting among fractions, decimals, and percents using a chart on the board created from the "matches."

April 24, 1995
T: Look at the chart we just created. It should be no surprise how we went from fraction to decimal and back to fraction, right? Even if it was terminating. But how do you find the percent? You did it, you matched up somehow.
[S answers.]
T: You said you didn't know how to do it, but somehow you matched up with two other people, and you were all correct. Did it just come to you from the heavens above?
[S responds] "Erase the decimal point and move it . . ."
T: What gives you the right to move the decimal point two spaces? What are you? King of the decimal point?!
T: How does Bart have the authority to move the decimal point two spaces any way he pleases?
S: [Responds.] Somebody made the law a long time ago.
T: Your technique is very correct, but I want to know why? The computations you have both given have been 100% accurate. But why?
S: Percent is per 100 . . .
T: Percentage per hundred, yes. Uh hum. She's on the right track, help her. Percent is per 100. Yes, I agree. And therefore . . .
S: You multiply by 100, which moves the decimal point over two.
T: Yes and no. Percent is per 100. Here we have .75 per 100. Take a look at that. Does it mean anything?

Contexts of Low Student Involvement: Ms. Duncan, Ms. English, Ms. Ford, and Ms. Grant

In the four lower involvement classrooms, the teachers' instructional approaches shared patterns of higher frequencies of nonscaffolding categories than scaffolding discourse. The discourse in these classrooms centered around high use of procedural talk and I-R-E sequences. Coupled with the high frequencies of teacher procedural talk, whole-class teacher discourse did not reflect a context in which students learned how to take responsibility for learning or were afforded the chance for autonomy. In addition, the teachers in the low-involvement contexts typically used more extrinsic supports than intrinsic supports. Compared with the high-involvement teachers' discourse percentages, the portion of teacher talk within the scaffolding categories was low.

Ms. Duncan. Ms. Duncan was a first-year teacher who was teaching a lower ability math class. She made more use of extrinsic motivation supports than the involvement teachers but fewer than teachers Ms. Ford and Ms. Grant. Her students rated the challenges of her lessons low and their skills as relatively high. Math lessons in this classroom ranged from procedural talk and I-R-E to negotiation of meaning. Therefore, Ms. Duncan did not fit into a consistent scaffolding or nonscaffolding pattern. Furthermore, there was little transfer of responsibility found in her lessons, perhaps causing students to perceive lessons as low in challenge and to experience low levels of involvement. In this excerpt, which includes only the beginning (156 words) of a 386-word explanation, the teacher was explaining how students were to create a budget with a list of typical expenses they might have during their first adult jobs.

May 5, 1995
T: You are to pretend that you have received your bachelor's degree from the college of your choice and you've taken a job. The salary you are to receive is $16,947 a year. Then you will need to figure out what your monthly salary is going to be. How will you know what your monthly salary is?
S: Divide by 12.
T: Why?
S: Because there are 12 months in a year.
T: Exactly. What you will do is divide that number 16,947 and I'm assuming this number is after taxes. You've already paid your taxes. This number is after taxes so you'll divide by 12 and whatever number you get is what your monthly salary will be. So that's going to be the first thing you will need to do. Then you will need to prepare a detailed budget at that salary for one year. And basically what I'm going to have you do is going to be a detailed budget for one month, your expenses for one month. You're going to have to make sure that um . . . you see the list at the bottom for rent, utilities, food, supplies, furniture. Some of those things we're gonna kind of wipe off there because we're going to assume you have some of these things. Some of these things are not going to be a part of your monthly budget.

Ms. Ford. Ms. Ford was in her second year of teaching, and taught a low-ability class. Analyses of her discourse indicated that she had one of the highest frequencies of using extrinsic supports (17%); Ms. Grant also had 17%). She often emphasized grades as the goal of the math activities in preference to learning and used inducements that focused on work completion or threats. Discourse analyses also revealed low patterns of scaffolding. Ms. Ford's students rated their skills as higher than the challenges across all lessons. In these two excerpts from the same lesson, Ms. Ford illustrates her view of grades while returning tests and her procedural, textbook approach to mathematics.

April 24, 1995
T: When I corrected these papers, I was really, really shocked at some of the scores. And I think you will be too. I thought there were some that were so-so, and there were some that were devastating, in my opinion.
S: [Noise increasing.] Can we take them over?
T: I am going to give them back to you. This is what I would
like you to do: Every single math problem that you got wrong, for homework tonight and tomorrow, it is your responsibility to correct those problems and turn them in. In fact, I will say this, I want this sheet back to me by Wednesday at least. All our math problems that we got wrong I want returned to me. I want this, I want this sheet back to me by Wednesday at least. All to correct these problems and turn them in. In fact, I will say like you to do: Every single math problem that you got wrong, Dad to be aware of how we're doing.

Ms. English. Ms. English, a teacher with 21 years experience, taught a heterogeneous group of mathematics students. Her instruction differed from the other teachers in that she had divided the students into two math groups, high ability and average, each with a different level of mathematic text. Students were assigned problems for homework and most class lessons consisted of the teacher evaluating textbook answers with each group. When new topics were introduced, the teacher called on students to read the introduction in the text and to work the sample problems aloud as a group. Sixty-five percent of Ms. English's discourse was coded as procedural or I-R-E, as might be predicted by lessons in which responding to the text was central.

The textbook appeared to determine the discourse in this low-involvement mathematics classroom. Although the textbook ability grouping possibly provided a level of moderate challenge, the discourse analysis revealed that the instructional approach was to demonstrate competence in working text examples. Given that Ms. English used fewer intrinsic and extrinsic supports than the other six teachers, students may have perceived mathematics learning as routine. Our discourse analysis revealed very predictable procedural talk based on following the text line by line and page by page throughout the course of our observations. The following lesson on percentage illustrates this text-based instruction.

May 17, 1995:

T: Okay, let's take a look at page 316. Who would like to read?
[S reads problem about computer.]
T: All right, now that is important to remember. When you're dealing with percent it is like you're dealing with hundredths. Okay, There's a... that's what percent means. One percent is the same thing as one hundredth. Eighteen percent is the same as 18 hundredths. Okay? All right, now look at “B.” It says write 4% as a decimal. You can write that as point zero four. Write .07 or seven hundredths as a percent. That would be written as 7%. Now think about it. Point seven is seven-tenths, right? Okay, 7/10ths is the same as 70/100ths. All right. All right. Okay, Kelly, “A.”
S: [inaudible.]
T: Point 51, or 51 hundredths. “B,” Marty?
[Teacher calls on more students to give answers.]
T: See, this is not a big deal. All right, let's take a look at page 318. And do I have a reader? Ann?
S: 80% [reads story problem.]
T: Okay. So, by changing your percent to a fraction, put 2 over a 100 and then reducing to lowest terms. All right, let's look at “B.” Seven-twentie...
Ms. Grant. Ms. Grant was an experienced teacher with 22 years in the classroom, who taught an average-ability class. Her lesson transcripts revealed one of the highest patterns of procedural discourse and of extrinsic supports. Ms. Grant’s discourse patterns reflected many instances of telling students what to do rather than teaching them how or assisting their learning. Ms. Grant demonstrated the least frequent use of negotiation, transfer, or intrinsic moves. In the following lesson on depicting information in circle graphs, students are reviewing information learned earlier (decimals and percentages) in the new context of using them in graphs.

May 2, 1995

[T begins the class by asking a student to read a story problem from the textbook chapter on using graphs to illustrate percentages. The text shows a pie graph that represents 100% of the American coastline, or 12,383 miles. The graph is divided into portions, such as 17% representing the Atlantic coastline. The problems consist of finding percentages of the total coastline in miles and reversing the algorithm.]

T: OK. This number represents 100%. So this total of 12,383 miles of the coastline is what it represents as 100%. It’s kind of a strange number but that’s what it is. Now it says that the Atlantic coast is 17% of that. So, how do you find 17% of 12,383? Remember when we did this... Rhonda... S: 5. [T writes what S says on the chalkboard.] T: No, it is 383. [T does not respond to this student.] T: And they did that in the book and it says that they came up with 2,105 and eleven hundredths. Yes?

S: Where did they come up with 17%?

T: Where did they get the 17%? That is a very good question. Where did they get that what do you think? [Students answer in the back of the classroom.] One thing you’d have to find out... that’s a good question Susan... what if all you knew was the 12,383. You had no idea that the Atlantic Coast was 17%, the Gulf Coast was 13%, the Arctic was... all you knew was this and then all you had was oceans.

S: Add them.

T: What if you had this number given, 2,105 and eleven hundredths. What if you had that given to you? How would you find out that was 17%? Let’s do this in reverse. What do you think Lance?

S: [Mostly inaudible] Subtract. . . .

T: Well, I don’t if I want to subtract. I might want to what?

Duh... [Makes beginning sound of “D.”]

S: Divide into.

T: I might want to what?

S: Divide.

T: Divide! This... What is this in relationship to this? So that it would be 2,105 over 12,383; what fraction is that? It turns out to be 17 over 100. It’s basically a reducing plan. OK, that went pretty fast for us, we’ll go over that again. Look at the pie chart here, use data from the circle graph. How much coastline does the Gulf Coast have? Thirteen percent, but it would be 13% of what? Andrew...

[Answer begun by students, then joined in by teacher.]

T: 12,383.

S: So that’s how we find that out. Which coast has the smallest amount of coastline?

S: The Arctic.

T: The Arctic. So how would we find out what the mileage is? We have to take 8% of... [Students begin to answer.]

T: [interrupts] Yes... we have to take 8% times 12,383.

[The next day, Ms. Grant illustrates several ways in which she provides positive reinforcement (extrinsic supports). In this excerpt the teacher is commenting on the pie graphs that she had assigned for homework.]

May 3, 1995

T: [Looking at student graphs]: Susan, what did you do? Oh... ooo... anyone else? Pretty colors. Laser printer... oh. This is high quality. Can you see the clarity? Really nice. Can you see why people want to spend their money on these printers? You can really see the difference. Look, I will pass this around for you to see. This is a standard printer and this one is printed on something called a laser printer and it is supposed to be fine-tuned printing. When people tell you they have a laser printer, you know they have high quality.

S: Can I collect all of the homework?

T: Oh, I want to share some of these really nice ones. Larry, you did not have a computer, but it is just as good, in fact it might even be better and it is absolutely gorgeous. Oh, Monica, yours turned out wonderful! OK, everyone hold them up and smile. They are sooo beautiful. I just love them all.

S: My mom helped me.

T: Well, tell mother it is just awesome!

Discussion

We examined students’ self-reports of involvement in mathematics classes and interpreted them in relation to the instructional discourse patterns observed in their classrooms. We defined involvement as the perception that the challenges afforded by the instruction and students’ skills were both high and fairly balanced. We supported this hypothesis with concomitant student reports of positive qualities of experience, such as involvement, intrinsic motivation, and openness. Qualitative analyses of classroom discourse showed that scaffolding of classroom instruction through whole-class discussions helped to create a context for and support of student involvement.

We found several important differences in the instructional patterns of high- and low-involvement teachers. First, there was a higher press for understanding and more provision of autonomy in the high-involvement classrooms. Because the tasks required greater cognitive and motivational effort, these teachers monitored students’ skills, persistence, interest, and emotional stamina to meet high standards (Gaskins et al., 1997; Lepper, Drake, & O’Donnell-Johnson, 1997). For example, when her students did not know how to begin, Ms. Adams modeled successful strategies such as reducing the large fractions to smaller equivalent ones. Ms. Adams’ modeling did not reduce the overall complexity or integrity of the task. Instead, it kept students engaged in the process by temporarily reducing the cognitive and motivational load so that they could make progress and feel more confident. In this high-involvement classroom, the teacher continued to press for understanding and justification, tempering it with humor (a reference to “fractional fractions”) offers of help (“Let’s... regroup”) and attempts to relieve frustration (“Let’s look at these a little differently because I think you’re getting bogged down... it seems a little overwhelming”). In contrast, when Ms. Grant wanted her students to convert 161/184 into a percent, she took over the task for them. (“Most of us don’t remember this but if we want to turn this into a decimal we would divide 184 into 161...”). Similarly, teachers frequently requested that students...
explain how they had solved problems and why certain solutions worked. For example, Ms. Benjamin asked her students to demonstrate different strategies and explained how they were equally effective approaches to problem solving ("How else could you deal with 3/5 other than Katy's strategy?"). In contrast, Ms. Ford suggested to her students why they could move a decimal point in converting decimals to percents ("What gives you the right to move the decimal point two spaces?"). In contrast, Ms. Ford suggested to her students that converting from millimeters to centimeters is "... simply memorizing this pattern.") By showcasing and asking for justification for strategies, the high-involvement teachers supported their students' autonomy as learners. Conversely, when teachers did not explain why one would perform an operation, they were essentially retaining ownership of the mathematical knowledge and failing to support the mathematical autonomy of their students. Student control is a central tenet of intrinsic motivation to learn, whereas controlling environments tend to decrease motivation (Deci & Ryan, 1989).

Second, the high-involvement teachers created a climate in which error was viewed constructively. When a student made a mistake and then corrected himself, Ms. Benjamin provided feedback rather than evaluation: "OK. Now you got it. You were saying it backwards. So if you had 5 divided by 8, that's what 5/8 represents." If a student could not answer, Ms. Adams did not go on to another for the correct answer but demonstrated that it was all right not to know. It was not embarrassing in her class for the teacher to hint, "When I round to the nearest 10th, Sandra, look at the ones if it's less than 5...." Students understood that Ms. Adams' priority was learning, not correct answers.

Traditionally, teachers have provided small amounts of information using easily learned skills that avoided error, especially in mathematics through "didactical contracts" (De Corte, Greer, & Verschaffel, 1996). These discourse routines reduce the complexity of the mathematical discussions as well as mathematical reasoning. Teachers' discourse patterns may reflect not only their theories of learning and motivation but also established classroom norms and expectations. Thus, teacher discourse may create an evaluative context in which errorless learning is viewed as effective and efficient and uncertainty is a sign of failure to learn. To support these perspectives, mathematical activities may be degraded to routines (e.g., Doyle, 1983), such as Ms. Duncan's admonition to memorize the "pattern." Teachers may take over the challenging aspects of learning, as Ms. Grant did ("'So that it would be 2,105 over 12,383; what fraction is that? It turns out to be 17 over 100'"). Or they may revert to telling students what to do (Stein et al., 1996), as when Ms. Grant mouthed the word "divide" so that her student would provide the correct answer. Guaranteeing that skills exceed challenges gains the cooperation of students and maintains a "comfort level" in the classroom because it avoids error and uncertainty (Doyle, 1983); it may also increase teacher efficacy, assuring them that students are learning. We found this pattern in several of the low-involvement classrooms.

A third difference between high- and low-involving instructional settings was that the high-involvement teachers seemed to exemplify for their students a respect for and an interest in the mathematics per se, what Brophy (1983) has called motivation to learn. One way Ms. Benjamin did this was by stating goals for learning ("The reason I have this in effect is ... you need to show me that you understood these concepts"). Another way was to encourage students to "value or enjoy the actual process of working on academic tasks" (Brophy, 1983, p. 211) by modeling their personal interest in mathematical relationships. Ms. Benjamin noted, "That's great. I just love that! Do you see what he did...?"

and, "I really wanted to teach a lesson about ratio today..." The high-involvement teachers in this study presented content as inherently interesting, assuming that students would build a personal interest in mathematics. In contrast, low-involvement teachers seemed to use right answers as the means to reach goals of completion or grades, assuming that math was something to "get done."

The findings in this study are limited by some methodological and interpretive factors. First, our methodology of analyzing teacher discourse to capture ecologically valid classroom events is most effective when there is a relatively equal amount of discourse in each classroom. When a teacher deviates substantially from the norm, such as spending half the instructional time in small groups, the discourse becomes less representative of classroom instruction, and perhaps, student experience. Second, data were drawn from seven classrooms in a middle-class school district with a relatively homogeneous population. This school district had the reputation of attracting skilled teachers. In addition, the teachers were volunteers, and thus may have represented a self-selected group who were more confident about their instructional skills. Given the reported predominance of procedurally focused mathematics instruction, our finding that three of seven teachers were successful at creating high-involvement mathematics classrooms may be atypical (De Corte et al., 1996; Hafner, 1993; Hiebert & Wearne, 1993). Because of our small sample, we cannot generalize to a larger group of teachers; nevertheless, we believe that these teachers may represent patterns that might be verified in larger or more diverse studies.

Third, students were asked to make a global assessment of challenge, skills, and quality of experience. It is possible that these ratings reflect the effect of different experiences across the class period. However, there was rarely more than one activity per lesson, and so we believe that any problem interpreting the responses might more related to generalizing across 50 minutes than to the confound of multiple activities.

To limit our disruption of the mathematics lessons, we confined our data collection to six student informants per class. We adapted ESF response forms developed for use with adults and older adolescents for younger respondents. Although we have confidence in the students' responses (based on the convergence among observations, discourse analyses, and student evaluations), further research is needed to determine whether children interpret the ESF's in the same way as older respondents. For example, some students' ratings of challenge and skill for the lessons might have been
confounded with other teacher characteristics such as warmth, knowledge, or experience. Although two of the lower involvement teachers were inexperienced, the other two had considerable experience. In the lower ability classes, teacher inexperience and student ability remain confounded. Similarly, students' metacognitive abilities to judge challenges in relation to their skills might have varied with ability levels in mathematics.

Conclusions

Although many studies have examined effective mathematics instruction or general reports of motivation in mathematics contexts, we found that instructional practices that coexisted with different levels of involvement were woven into the content and processes of instruction. Thus, involving instruction in mathematics will differ from that in other content areas because of teacher and student assumptions about what counts as learning in this subject area (Stodolsky, 1988). Concurrently, much research in motivation has been conducted in experimental settings with nonacademic tasks or via surveys and has not addressed the complex relationships among instruction and motivation. By contextualizing student motivation in a subject area such as mathematics, researchers can provide both descriptive and prescriptive information for future research and classroom practice.

The findings of this study prompt other important questions that might guide further inquiry into the relationship between involvement and instruction. For example, in three of the seven mathematics classrooms in this study, we found evidence that involvement was socially constructed through the development of mathematical disposition, or the "tendency to think and to act in positive ways" (National Council of Teachers of Mathematics, 1989, Standard 10, p. 233). Teachers did this *motivationally* and *emotionally* by providing intrinsic supports, such as bolstering students in feeling confident, persevering, developing interest and curiosity, and appreciating mathematics as a tool and language. The teachers also supported student learning *cognitively* through negotiating, or balancing students' knowledge and skills with the challenges of new understandings and by transferring responsibility for learning to them. But how common is the scaffolding of involvement during whole-class mathematics instruction? How do teachers develop the pedagogical strategies and the knowledge and commitment to mathematics that the high-involvement teachers illustrated?

Furthermore, we found that teachers involved students through the discourse of scaffolding, but there are other scaffolding structures to be explored, such as small-group activities or peer or parent tutoring. We found that discourse was a compelling indicator of an involving classroom context, but we examined only the teacher's contributions to classroom discourse. Therefore, we suggest that student contributions to discourse should be examined more closely. The reciprocity among teacher and students in creating an involving learning context needs to be explored. How do students' knowledge, affect after failure, or goal orientations contribute to a classroom context that supports scaffolding and involvement in learning? Finally, how might involving instructional practices, such as scaffolding, differ across content areas or developmentally across grade levels?

Involvement has been studied as an individual psychological experience, but we believe it can be a shared experience and may be developed through participating with others. Thus classrooms are, and can become, places where the necessary conditions of involvement are set in place. Future research will require integrating the individual viewpoint with a social perspective for studying involvement. Furthermore, we must differentiate engagement from involvement, for only then will we be able to untangle the necessary from the sufficient classroom conditions that support students' and teachers' involvement. Finally, we must continue to explore new ways for measuring situated motivation and develop more nuanced understandings of how involving classroom experiences are created by capturing context as part of our research methods.

References


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