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ABSTRACT

Current educational reform movements focus on mathematics teaching for the empowerment of students and on the classroom as a mathematical community in which students themselves actively question, negotiate, and construct mathematical ideas through classroom discourse. This paper discusses a study that focused on students' use and perception of communication in the algebra classroom. Observed in the study were (n=65) students from two algebra classes of a teacher dedicated to changing her teaching methods, and in particular the classroom talk, from traditional interchanges to the type of discourse recommended by the NCTM Standards. Five students from each class agreed to serve as key informants and to participate in a journal exchange and interviews with the researcher. Discussions include summaries of the students' views prior to analysis, teacher's answers as an influence on student questions, and typical and exceptional dialogue patterns. Contains 10 references. (MKR)

Identification of Student-Question Teacher-Question Student-Response Pattern: Students' Interpretation of Empowerment

Proposal for a Research Reporting Session
at the
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Current educational reform movements focus on mathematics teaching for the empowerment of students and on the classroom as a mathematical community in which students themselves actively question, negotiate, and construct mathematical ideas through classroom discourse (National Council of Teachers of Mathematics, 1989; National Council of Teachers of Mathematics, 1991). Hadley (Hadley, 1990) identifies the practicing teachers as ultimately responsible for the classroom implementation and evaluation of most goals described in the *Curriculum and Evaluation Standards for School Mathematics (Standards).* However, Sarason (Sarason, 1982) suggests that teachers in general are so familiar with the way that classrooms function that they are not cognizant of the culture of the school and the complexity of students' roles in that culture. Students' interpretations of their classroom environment as they learn to participate in a classroom community that reflects the spirit of the *Teaching Standards* thus merits investigation (for additional discussion see Walen, 1993). This study focuses on students' use and perception of communication in the algebra classroom and reveals, among other important perceptions, an unexpected common student response to their teacher's attempt to make them aware of their individual mathematical power.

Conceptual Framework, Procedures and Design

An interpretive conceptual framework combined with mixed methodology was used to identify and analyze students' communication efforts as they participated in two algebra classrooms. Participant observation methods were employed to gather continuous data throughout the academic-year long study of 65 students. After two and one-half months of classroom observation, 5 students from each of two algebra classes agreed to serve as key informants and corresponded with the researcher in dialog journals. Individual students determined the topics and frequency of the journal exchange, which varied from 4 to 0 exchanges per week. Following 8 weeks of journal exchange, the key students participated in individual 40 minute structured interviews. Salient items from these interviews lead to questions for an open-ended written questionnaire completed by all students. Responses were analyzed for additional emergent features and distilled to form a Likert questionnaire administered to both classes in order to determine students degree of sensitivity to key issues.

Key Students

Six of the key students represented a continuum of typical student response groups. These groups did not constitute well-defined sets, but formed sets with non-distinct boundaries. The fuzzy bounds that held the key students to their constituent groups faded and became clearer depending upon the context. The following summary of two individual key students provides a brief introduction that places their views in a clearer picture for analysis of the teachers attempt to empower students.

Jane was an overtly verbal, bright, amiable 15 year old freshman girl. While her participation style was free and exuberant, she acknowledged the necessity to maintain awareness of other students' classroom needs. Jane participated in the classroom in almost the ideal manner described by the *NCTM Standards* student communication expectations. Her specific classroom success provided a stark contrast to other students who found change difiicult.

Ray was a stocky, bright, friendly, yet moody 15 year old freshman boy. He appeared confident and engaged during interactions with other students in small groups or outside of class. However, this contrasted with his aloof manner during whole-class discussions. Ray provided an interesting contrast to Jane. He valued mathematics in general, but he had no personal commitment to learning algebra.

Fred was a slight, verbal, often self-conscious 15 year old freshman boy. He talked about growing up on the farm and thinking that school was essential for him for socialization purposes. Fred was an interesting student, willing to continue to do what he saw as his job in the classroom (memorized facts that he did not value), but only if that job did not conflict with his primary social concerns.

Beth was a tall, athletic, bright, hard-working 15 year old freshman girl. She saw her own assumption of a leadership role in the classroom as similar to her perception of her parents roles in the community. Beth, like Jane, knew that there were times in which other students did not approve of her participation or concern for excellence, but she was unwilling to give credibility to those comments. Beth had perhaps an ideal combination of classroom frames and a practical realistic view of learning.

Emy was a tall, blond, too-serious 16 year old high school sophomore. Emy saw effort as the only element necessary to succeed and algebra as holding questionable value. She did not see mathematical connections but memorized until it became automatic. She, above all, was determined and maintained a positive attitude.

Pat was a petit, friendly, socially conscious 15 year old freshman girl. Pat viewed mathematics similarly to Emy with the exception that Pat's attitude towards algebra caused her frustration and anger. Pat did not direct her anger towards herself or the teacher but towards the reform elements in the classroom.

These six students were generally amiable students. Each of them, in their individual way, provided insight into the classroom. The following section addresses the ways in which their idiosyncratic views came together to provide a reasonableness to their school interactions.

Teacher's Answers as an Influence on Student Questions

Students in this study indicated they expected school dialog to be different from everyday conversations. However, they found particular teacher responses problematic. According to these students, classroom dialog between students, and especially between teacher and student, required a concerned response from both participants. Un-stated classroom rules dictated that when students were asked a question by the teacher, they were obligated to give a direct response, the best answer possible. These rules were influenced, shaped, and enforced by previous teachers and this teacher through responses given following student answers. These responses have been typically identified as the E of the IRE (inquiry, response, and evaluation) classroom conversation style described by Mehan (1979)

These students also expected teachers to provide them with answers as they asked. However, when asking this teacher a question, these students often did not receive a direct response. From their perspective the rules for classroom answers in this new environment were different for students and teachers and they did not interpret the situation as intended by the teacher. The teacher explained she did not prefer to give a direct answer to student questions because she "wanted to get the kids to think." She often responded to student inquiries with "It really is simple. What do you think the answer is?" Although her intentions were well founded, this type of response caused much frustration for most students.

The tension between what they had learned to expect through their social conversation and how they interpreted certain classroom settings was evident in how they described teachers' answers to their questions. This misinterpretation did not become obvious in whole-class observation, but rather as response to an open-ended question "What advice would you give a new teacher that would help them be better math teachers? Try to describe one thing that you like in a teacher and one thing that 'drives you nuts' and that they should never do." Without exception, students indicated that teachers should answer their questions.

Table 1
Responses for 6 Target Students and 46 Non-target Students on 7 Likert Items about Views on Teacher's Answers

	Likert Responses										
	Individual						Percent of Students (N=52)				
Teacher's answers are...	Jane	Ray	Fred	Beth	Emy	Pat	Yes!	Yes	?	No	No!
1. helpful when they give me just the answer	?	Yes!	Yes	?	Yes	Yes	17%	29%	15%	29%	10%
2. helpful when they give me both the answer and the explanation of how the problem works	Yes!	Yes!	Yes!	Yes!	Yes!	Yes!	69%	14%	12%	4%	2%
3. frustrating when the teacher answers me by asking me more questions	Yes!	Yes!	Yes!	Yes	Yes	Yes!	52%	25%	17%	4%	2%
4. irritating, when they don't give a direct answer. I know they are trying to get me to think, but when I ask a question I need an answer	Yes!	Yes	Yes!	Yes	Yes	No	46%	25%	21%	6%	2%
5. humiliating when they tell me 'you know this' or 'this isn't hard'	Yes	Yes	Yes!	?	Yes	Yes!	44%	31%	12%	14%	0%
6. unkind when they talk all around my question, I feel like what I asked wasn't important	?	No!	Yes!	?	?	Yes	35%	23%	27%	14%	2%
7. fake. They cover-up for the fact that they don't know.	No!	No!	Yes	No!	?	?	12%	4%	2%	17%	46%

Recall that the data sources for the Likert stem response choices shown in Table 1 were the key students' responses and general responses to the open-ended survey instrument. The majority of key students' interview comments regarding teachers' answers and whole-class open-ended survey written comments held a negative tone. Therefore, these particular questions on the Likert questionnaire reflected this mood. Students' recollections of embarrassment resulting from the interpretation of a teacher's answer to their question may have been the source of this sensitivity. Many students were concerned with and talked about balancing social and academic elements in the classroom. Although the teacher had made attempts to inform the students of her intent to "get the kids to think," part of the students' frustration at not receiving answers was in not really understanding. Some students stated that although they knew that a teacher was trying to get them to think by not answering, this did not eliminate the frustration that they felt (see Table 1).

Giving good answers was, according to most students, the "teacher's job." Students often said they thought teachers had all the answers. Jane related her thoughts about the teacher knowing the subject material.

Every once in a while she (the teacher) will say, "I don't know, you tell me." [Probe: Do you think she really knows, but wants to get you to think, or do you think she really doesn't know?] Usually, I think she knows. 'Course I think that that's my mind set towards teachers. Umm...I don't know. It's an interesting question.

Jane also provided further explanation in the interview that indicate she could not ever remember a time when the teacher did not have the answer to a question that the teacher had asked. Ultimately, Jane felt that teachers had all answers.

Ray, too, knew that teachers had answers to questions. His response provides an elaboration to how students thought about teacher's subject knowledge.

In subjects like math, I don't think that will ever happen [a teacher did not have an answer to a question that they asked], but when you're reading a book or drawing something, or making something up on your own, they will ask questions that they don't...you know, they don't know about.

Ray allowed teachers the privilege of not knowing something in areas like art or literature, but mathematics was known and "most teachers nowadays know what they are doing."

Beth was the only student interviewed who stated that teachers might not have some answers, but those were answers to student questions. Teachers, however, always had answers to their own questions. This perspective gave rise to the view that teachers mostly had answers to content-area questions in mathematics. If a teacher had the answers and chose not to help a student, Beth did not interpret this withholding of information as a teacher's vote of confidence in her ability, but rather a vote of dismissal for the importance of her question. The data suggested that students interpreted their questions as being "unimportant" or "dumb" if they were not answered by the teacher. Beth expected herself to be "a good student," able to ask "good questions," and considered it important for a teacher to answer :r questions. Several other students suggested that although "questions were the only way that you could learn anything" there were problems with the teacher's answers. Many students repeatedly responded in journals and interviews with "If I knew what the answer was, I wouldn't ask." These students expected to get the help that they needed (see Table 1). They had worked hard before asking, tried everything that they knew, failed, and asked someone they knew could help. From their way of knowing and looking at the world, they were being dismissed. Their question was not important; it was something that they should be able to do. They felt anger and frustration. Their previous experiences in classrooms and their interaction expectations from outside the classroom consistently did not fit the new classroom model of question-asking and -responding.

Classroom Talk

The data from this study indicated that both the students and the teacher found it difficult to alter previously established classroom patterns of dialog. Possible reasons include students' perceptions of mathematics and the students' basic lack of a sense of dependability in the structure of mathematics. In addition, the comfort experienced by both student and teacher in traditional structured mathematics classes also may have been an impediment to change. People in general do not seem to wish to change long established traditions, even when that tradition is not seen as particularly productive. Nevertheless, the teacher and the students were able to vary the classroom talk from typical lessons that contained typical traditional classroom dialog to exceptional lessons which contained more diverse conversational components.

Traditional Lessons: Typical Dialog Patterns

This teacher, like many other teachers (Good, 1990), felt most comfortable working within a whole-class instruction format and

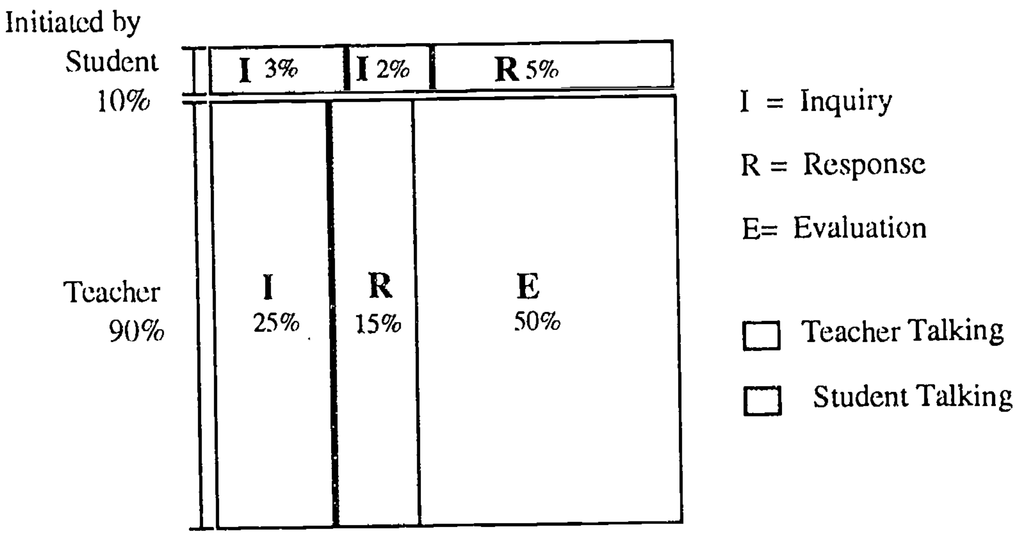

Figure 1. Discourse in a Typical 50 Minute Lesson

regularly chose that method of instruction. Along with whole-class instruction, the teacher structured certain lessons around group activities; however, small group interaction patterns were not the focus of this study. The teacher's intent and the students' willingness to comply did not successfully bring about substantial change from the traditional classroom interaction during what was identified by the researcher as typical content-driven whole-class lessons. Lessons revolving around worksheets or assignments given from the text continued to be typical throughout the year and consisted primarily of traditional, though slightly modified, IRE interaction.

While the majority of the observed lessons represented a traditional format, these traditional lessons also indicated shifts towards more substantial changes in classroom dialog. Subtle changes in student responses to teacher inquiries and a pattern of teacher response to student questions provided further insight into the difficulty many students had in complying with the teacher's vision of the classroom.

Figure 1 represents data from a typical lesson. This data was collected from text- or worksheet-based whole-class lessons randomly selected over a five month period. Interactions in these lessons were sorted into categories, words in the categories counted, and the data were combined as representative of typical lessons directed by mathematical content presented in text or worksheet format.

While these lessons reproduce a traditional dialog pattern, this pattern in itself was not indicative of the level of the interactions nor was it particularly undesirable. Student inquiries in these lessons were exclusively algorithmic in nature and not representative of the goals described by the *NCTM Standards* and adopted by the teacher. Two particularly interesting dialog patterns became evident during analysis of typical lessons: student-question teacher-question student-response pattern (IIR) and student-response modification.

Student-Question Teacher-Question Student-Response Pattern (IIR)

Identification of the IIR interaction format provided clarification of the students' previous sensitivity to issues regarding their teachers' answers to student-generated questions. Teacher inquiry immediately followed 49% of student-initiated questions identified in a random sample of eight whole-class text- or worksheet-based lessons. In 30% of these IIR interactions the teacher responded with a question to clarify the student's inquiry and then followed with a response. Students did not mention this type of IIR interaction as troublesome. However, in 70% of the IIR interactions, the teacher's only response was a question which returned the original question to the student. At times the teacher modified the original student question but in most cases the teacher expected the students to answer their own questions. An example of both forms of the identified IIR classroom interaction pattern occurred during a discussion of the use of the distributive property. The teacher had previously demonstrated the distributive property of multiplication by use of a monomial-binomial product. Jane was eager to participate in the discussion and asked about the more complicated monomial-trinomial product.

Line 1 Jane: What if there was 3x?

Line 2 Teacher: On the inside?

Line 3 Jane: Yeah.

Line 4 Teacher: It's a good question. [writes 2(3x+a+2) on the board] Jane
Line 5 asked what if you have a number in front of the a plus 2. Now
Line 6 what? What do you think, Jane?
Line 7 [Jane correctly provides a solution to the problem.]

Lines 1 and 2 illustrated the teacher's need to respond with a clarifying question. Students in the two algebra classes never mentioned an interaction of this type involving a clarifying response as a source of embarrassment or worry. After Jane affirmed the teacher's interpretation of her question in Line 3, the teacher responded (Lines 4-6) to Jane's original question with a question. Jane then provided the solution (Line 7) to her original question (Line 1). This last example illustrated the identified troublesome IIR pattern. Jane's interaction did not cause her any concern because she could extend the algorithm successfully. In this case the teacher's intent to empower Jane was successful and the IIR pattern did not provide a source of difficulty. However, the following interaction between Beth and the teacher illustrated the IIR pattern can be interpreted differently by student and teacher.

Line 1 Beth: Does it matter if you go ab or ba?
Line 2 Teacher: Is 3 times 2 the same thing as 2 times 3?
Line 3 Beth: Yes.
Line 4 Teacher: Why do you suppose we write a times b this way [points to ab],
Line 5 Beth?
Line 6 Beth: Because that's the way it appears in the problem?
Line 7 Teacher: Because that's the way it appears in the problem. What's
Line 8 another reason? Think how the alphabet goes...abcdefgh...that
Line 9 sounds pretty simplistic, but that's the reason. It's just easier for
Line 10 everybody if you do. Do it in chronological order and you do it in
Line 11 alphabetical order. It's just easier. Questions?

Lines 1, 2 and 3 illustrate the IIR interaction which caused Beth concern. Two different conflicting perceptions of the interaction were held by the teacher and the student. The teacher modified Beth's question and returned it to her in an attempt to show Beth that she could "logic out" her own answer. However, contained within the teacher's question was the assumption that Beth understood the concept of the commutative property for whole numbers and had not just memorized "3 times 2 is the same thing as 2 times 3." The teacher also assumed Beth would make the connection between the commutative property for multiplication of whole numbers and Beth's question regarding variables. Finally, the teacher assumed that Beth's "Yes" answer to "Is 3 times 2 the same thing as 2 times 3?" was an answer indicating she understood that ab was equal to ba. The conversational turn in Lines 4-5 indicated that the teacher was satisfied Beth's question was answered and wished to continue with the lesson. The teacher's addition of a novel point of interest to the algebra lesson in Lines 7-8 caused a change in the topic under discussion. Through a combination of interpreting the teacher's information as a change of subject (Lines 4-5) and viewing the teacher's answer as insufficient (Line 6), Beth saw her original question as dismissed. Although the teacher asked for questions in Line 11, the order of the conversation and the teacher's manner indicated those questions should be on the new information provided in Lines 7-10 or additional questions from other material. After this exchange, Beth expressed her perception of this interaction. She had not obtained the answer to her question, "Does it matter if you go ab or ba?" Beth thought that her question was "dumb," that she should have known the answer, and though she still did not understand she could not ask again during the lesson. Some students might have given up, but Beth waited until she could talk to the teacher by herself and asked again.

As Beth and the teacher took part in the interaction, each made assumptions about the other. The teacher worked from an expert's perspective and had most likely forgotten what it was like not to know that ab equaled ba. She did not remember the thought or the time and effort it took for her really to understand the ideas involved in Beth's question. She assumed that a simple reminder from arithmetic would allow Beth to make connections and feel powerful in her knowledge and ability to answer her own question. This may have been the result if Beth had made the connections that the teacher expected. However, Beth did not, and the result was that Beth felt bad about her question, bad about asking questions during the lesson, and ultimately bad about herself.

The miscommunication described in Beth's IIR classroom interaction pattern was not an isolated classroom event. The teacher's wish to empower students whenever she could by returning their question to them resulted in an unintentional tacit message to students. An interpretation of that tacit message came through in their primarily negative interpretation of the teacher's response to their questions. The students did not verbally interpret the tacit message but did reflect this message in students' talk of "stupid questions" and "stupid mistakes." Examining a parallel situation within the students' out-of-classroom interactions provided one reasonable interpretation of the student's talk.

Line 1 Fred: Are you going to the Sophomore Pizza Feed before the game tonight?

Line 2 Ray: DUH [Other students laugh]

In this dialog segment of student conversation during the break before the lessons began, Fred and Ray had been talking of last week-end's activities. Fred then went on to ask about Ray's plans for attending both the basketball game and the Sophomore classes' fund raising activity before the game (Line 1). Ray's response of DUH said with a long drawn out statement like intonation was sent to say "Of course I am going. What a stupid thing to ask." This was not an isolated interchange, if a question was considered to be "dumb" the student being asked responded by making noises such as "Duh?" or "Huh?" Another common response to a "dumb question" involved repeating the question with an exaggerated inflection and tone that indicated astonishment that the question could ever have been asked.

The classroom IIR pattern that resulted in sensitivity to teacher's responses contained elements of the students' social interactions. This social interaction formed a reasonable parallel for students' interpretations of the classroom. If the question was good, then it was important enough for the teacher to talk about it. If it was a "dumb question," then the teacher repeated the question as a response. If the teacher repeated the question, then it was a question that they should not have had to ask. Even more evidence of the "dumb question" was given when the student could answer his own question. An additional complicating factor was students' views of mathematics as not dependable and their difficulty in justifying mathematical processes: students were unable to evaluate the quality of their question before asking. These two factors made most questions risky and non-algorithmic hypotheses almost non-existent in most structured classroom lessons.

Student-Response Modification

During whole-class text- or worksheet-based instruction the teacher encouraged students to justify their answers. Although many students could not justify mathematical processes, the request for justification provided an opportunity for students to attempt to verbalize their thinking processes. This also gave all students an opportunity to hear and see how their peers thought about particular problems.

As the year progressed, the teacher deliberately made an effort to allow for student justification of mathematical problems and concepts. She began to modify the classroom dialog by asking "Why?" after student responses. This teacher-imposed "Why?" was very difficult for many students to answer, since they had little experience in providing mathematical justification and many felt a basic distrust for mathematics. Although the mathematical curriculum contained both unexpected events and errors as driving forces for student questions, the teacher's "Why?" represented a distinct type of question, the why of mathematical justification. In an attempt to encourage students to justify or to "logic things out," the teacher provided a model for the students to follow. Her non-judgmental manner indicated she was aware of the difficulty that students found in justifying mathematical processes.

Line 1 Teacher: OK, what do we have here? [writes $\left(\frac{3}{2}\right)^2$]

Line 2 Jane: Nine-fourths.

Line 3 Teacher: Nine-fourths, why is it nine-fourths?
Line 4 Jane: It's three-halves times three-halves.
Line 5 Teacher: OK, it's three-halves times three-halves because it's three-halves
Line 6 quantity squared as in parentheses. Remember the exponent
Line 7 affects whatever it's closest to. In this case we have parentheses
Line 8 and you know the order of operations, when we have parentheses
Line 9 you do what's inside. So everything that's inside the parentheses
Line 10 will be squared. [writes $\left(\frac{3}{2}\right)^2 = \frac{(3)(3)}{(2)(2)} = \frac{9}{4}$]

The teacher's request for Jane to justify her answer in Line 2 resulted in a procedural answer (Line 4). When the teacher asked Jane "Why is it nine-fourths?" Jane responded with the two values she multiplied together to get nine-fourths. The teacher repeated Jane's answer in Line 5 and continued in Lines 6-10 to model for Jane the type of answer that she expected. Lines 6-10 traditionally form the evaluation portion provided by the teacher in an IRE response pattern. Throughout the year, the teacher accepted the method by which students obtained an answer as well as actual justification as valid response to her "Why?" The transition from procedural justification "how" to formal justification "why" was seldom present in student responses. Students occasionally anticipated the "Why?" and voluntarily included a "Why?" as part of their response before it was requested by the teacher. In this manner they established a modification of the traditional IRE classroom communication pattern. The evaluation of the response (the E of the IRE sequence) originally was part of what the students saw as a classroom teacher's responsibility. However, by including justification as part of their response, they assumed a portion of the IRE pattern traditionally belonging to the teacher.

Line 1 Teacher: OK, then we have the result is twelve greater than the opposite
Line 2 of a number. The opposite of a number, lets talk about that for a
Line 3 minute.
Line 4 Ray: Well, we put the negative sign there 'cause you don't know if it's
Line 5 negative or positive.
Line 6 Teacher: Which negative sign, please, this one? [indicates -n] OK, how
Line 7 do we work that now?
Line 8 Ray: Well, it says OK, let's assume that it's positive. Even if it is a
Line 9 negative number, then the negative of it would change it to a
Line 10 positive and if it's positive then it would be negative. The negative
Line 11 will always make it the opposite, it doesn't matter whether it is
Line 12 negative or positive.

Line 13 Teacher: OK, negative n is the opposite of a number, we have it here, and
Line 14 we have it here. We have it here. OK, everybody is cooking so
Line 15 far. I want to know why the twelve.

Notice that the teacher did not start the interaction in Lines 1-3 by asking a question, but by requesting that they "talk." Interestingly, Ray responded in Line 4 by stating why he placed the negative in front of the variable. Ray justified his solution through describing the necessity of his logical choice for a negative to precede the variable in Lines 4-5. The teacher responded with a clarifying question in Line 6 and a request in Line 7 for the student to continue. Ray followed in Lines 8-12 with his justification for the choice of -n. Notice the limited amount of teacher evaluation in this exchange compared to the previous interaction with Jane. Although the teacher provided an evaluation of Ray's answer in Lines 13-15, this evaluation was limited to repeating what he had just said without expanding on his idea. The interaction in this conversation, although not a substantial departure from the traditional IRE, provided an indication of talk in transition. The teacher's "Why?" may have been a model that exposed students to sample justification arguments and provided a basis for forming questions themselves in other less structured lessons (as indicated in the data) or perhaps in future mathematics classes.

Exceptional Lessons: Exceptional Dialog Patterns

Throughout this study it became evident there was a distinct difference between certain algebra lessons. These changes in classroom dialog occurred during lessons or lesson segments marked by the students' sense that the teacher did not have a particular lesson to teach and it was OK for them to take control.

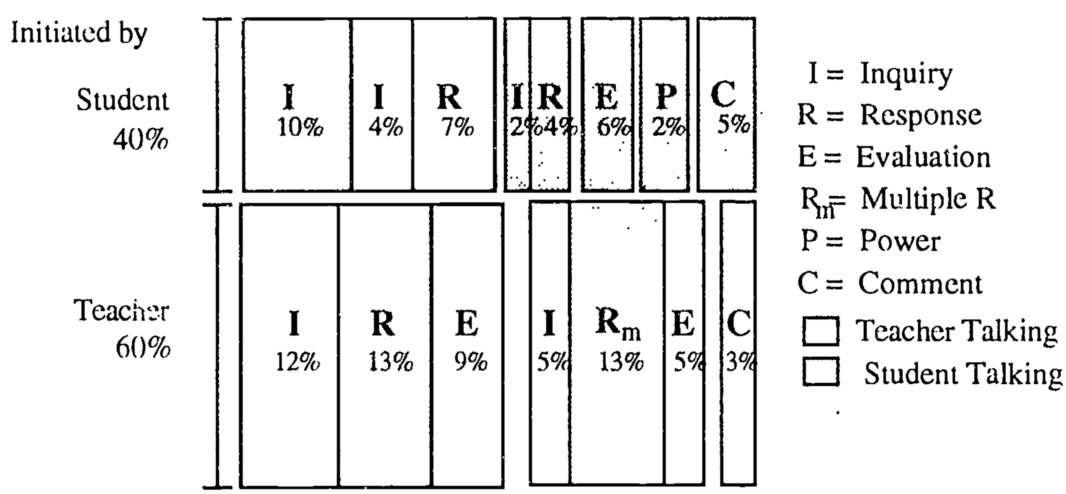

Figure 2. Discourse in an Exceptional 50 Minute Lesson

The lessons under consideration were not lessons taught "from the book" or "from a work sheet." The participation structure during these segments followed a relaxed version of similar rules followed in more formal lessons. When the students saw what they interpreted as almost a free day, they acted as though they were free from the structure of the traditional classroom perceived by many as part of learning the content of algebra.

Figure 2 illustrates interaction components and patterns present in an exceptional whole-class lesson. The exceptional lesson included dialog components identified in text- or worksheet-based whole-class lessons and components unique to exceptional lessons. Interactions illustrated by Figure 2 were more representative of the goals identified by the *NCTM Standards* and the classroom teacher than those illustrated by Figure 1. In particular, notice that student questions occupied less than 3% of the total time for a typical lesson, while student questions involved 12% of the total time for an exceptional lesson. In addition, the nature of student questions during a typical lesson was algorithmic. Although student questions maintained primarily an algorithmic nature during the exceptional lesson, 3% of the questions were at a higher level. Increases in the number of non-algorithmic questions and in the diversity of the interaction components provided a strong difference between the two lesson types.

Student-Student Interaction (IR) and Multiple-Student Response(R_m)

Conspicuously missing from Figure 1 and present in Figure 2 were categories composed of student-inquiry student-response pairs (IR) and multiple-student responses (R_m). The teacher had previously attempted to encourage student interaction by requesting students to "pass a question" during discussions in whole-class text- or worksheet-based lessons. As an example, consider the following interaction. The teacher had described her intent to the students and had requested that each student who performed a step in the solution to a problem choose the next person to participate in the solution. Tom had just provided a step towards the solution of the problem under discussion.

Teacher: OK, you pick somebody to do the next step. [to Tom]

Tom: Andy.

Teacher: Andy is that what you said, Tom? [nods] OK, Andy, next step.

Andy: [laughs] I don't know.

Teacher: You pick someone then.

Andy: Umm...Ray.

Ray: It equals negative three to the first times negative three to the minus one, or negative three to the one minus one.

The students in the two classes resisted "passing" the next segment of a problem or question. Each time the teacher attempted to have students pass or share the problem under discussion, the students acted as though they could not remember what they were to do next. The students' hesitation in adopting what the teacher saw as a group method for sharing work caused the teacher much frustration. However, she continued to request students to share the work by passing the problem. One particular day the teacher finally spoke with resignation, "OK, now what? Come on, come to out there, you have a responsibility for this class, too. I shouldn't have to pull this out of you all day long. You guys have to help. What's next. All right, I'll start calling names." This interaction ended the teacher's attempts to assist the students in naturally sharing the work in text- or worksheet-based lessons. However, when the lesson topics were not based on material in the text or a worksheet, students volunteered to assist each other in whole-class discussions. These interactions took place naturally without teacher direction or intervention and were evidence of student willingness to participate. The following example of a student-inquiry student-response pair (IR) naturally occurred during an exceptional lesson.

Student 1: Why?

Jane: Because you are dealing with the ones' places, tens' places, and hundreds' places. If you have eleven-hundred, that's the same thing as one-thousand one-hundred.

Student 2: Right.

Jane: So you just add the three thousand over there so you are adding the one thousand to the three thousand and you still have that one hundred left over. It's just simple adding.

Multiple-student responses (R_m) seldom occurred in text- or worksheet-based lessons but were evident as a part of the discourse in less formally structured lessons (see Figure 2). The following exchange represented a sample of the type of interaction classified as multiple-student response to teacher inquiry.

Teacher: The answer is 768 for this. Do you agree with that out there? Two times four is eight.

Student 1: Well, that will get the middle number, but I had three on top.

Pat: Three times two is six.

Student 2: Then you add them.

Student 3: Ugh. Let's just watch the movie again.

Beth: Seventy-two times twelve. I figured out like Pat's way that you times...how'd you get eight before...I don't know how to get the six like she did, but seven plus two minus three equals six.

Student 4: Man...then there's all this different stuff.

Lessons containing R_m participation structure indicated that some students were both capable and willing to alter the traditional IRE classroom discourse. However, previously identified components facilitating this change were not readily available for all students.

Student Evaluation Statements (E) and Comments (C)

Evaluation statements were identified as common elements in traditional IRE classroom interaction. However, the E element from an IRE interaction pattern traditionally involved a teacher's evaluation of a student's statement. During the analysis of exceptional whole-class discussions, students volunteered evaluations as they themselves offered justification, as other students answered questions, and as the teacher contributed to the discussion. Students did not bid for a turn to speak but simply stated their comments. On these occasions students were polite and did not seem out of order as they offered their evaluations. Rather, student evaluation statements fit into the flow of conversation and became part of the force that directed the discussion: "Three plus four plus one plus two...it doesn't work." and "Yes, that works." Unsolicited evaluations indicated active student participation. These evaluations did not interrupt the particular student leading a discussion but rather assisted that student in evaluating and directing his or her argument. This extension could be considered evidence of the formation of a classroom community in that students began to take notice of and evaluate other student's answers or conjectures. This active involvement among the students reflected a step towards establishing the learning environment as suggested by the *NCTM Standards*.

A comment category for certain statements made by both teacher and students was necessary when interaction components were identified as similar to evaluations and yet were not evaluations. Comments (C) were different from evaluations in that these statements did not expressly address the correctness of a particular statement or series of statements but rather commented on the discussion itself. Additionally, these comments required no response, did not directly alter the discussion, and could not be grouped as inquiry. Thus, specific student statements found in whole-class non-text and non-workbook centered lessons such as "It would take a long time to memorize all of them" and "That's the same thing as saying twelve times seventy-two. And multiplying by two. It's the same process as we used with twelve" formed representative statements classified as comments. The teacher often provided comments during these lessons. Her comments were similar to those stated by the students. "You guys all know how to plug numbers in. Here you are trying things" and "That's curious" represented statements classified as teacher comment (see Figure 2).

Teacher and student comments allowed individuals to maintain a place in the classroom interaction without actually participating in directing the mathematical discussion. A comment allowed an individual to join the classroom interaction without making an evaluation of a previous statement, changing the direction of the classroom discussion, or requiring another participant's response. The teacher used comments to participate in the discussion while allowing students to continue directing the discussion. Students used comments to participate when they wanted to be part of the discussion but did not wish to evaluate or direct the discussion.

Power (P)

Particular statements classified as power (P) were identified in the lesson diagrammed in Figure 2. More formal text- or worksheet-based lessons (see Figure 1) did not contain this type of statement. Questions or statements were considered power statements if they were made by the students as a suggestion for discussion or altered the direction of the lesson. Power statements were evidence of students' willingness to assume responsibility for directing the lesson. Students often used power statements without first gaining permission to speak. Power statements were often offered in a sense of spontaneous excitement that prevailed over their standard classroom behavior rules, which required teacher acknowledgment before taking the floor. Two particular types of power statements follow: "Try it with another number not 12" and "I've got a pattern. You multiply the two numbers and you add the two numbers."

"Try it with another number not 12." directed the teacher to provide another example of a particular process. The tone that the student used in this power statement indicated that it was not a request stated as a command such as "Please, try it with another number not 12." or a question "Would you try it with another number not 12?" Rather, it was a command and was not the type of statement that these students would normally say to their classroom teacher. Under tacit classroom rules, students did not tell the teacher what to do without a request from her to provide direction. However, within the less formal setting provided through lessons taught without text or worksheet, students responded as though directing the teacher and the lesson were their responsibilities.

"I've got a pattern. You multiply the two numbers and you add the two numbers" was an example of a student hypothesis. Although students stated hypotheses as statements rather than as interrogatories, they were considered a type of student-generated question. The act of conjecturing was an advanced process rarely found in the algebra classes. However, within the less structured format of the exceptional lesson a student was able to just guess. This guess led the discussion towards establishment of a non-traditional multiplication algorithm in the following lesson.

Students had previously stated the teacher directed lessons. However, during exceptional lessons they provided statements that directed the lesson (P). The students did not see an "unwritten" lesson in the same rigid manner that they viewed their text or worksheets. It was not uncommon for these students to view the mathematical text or the teacher as the ultimate authority. When the material was not generated through written format, the students performed as though the mathematics was not rigid or exact, but rather something to be negotiated and validated. Their previously discussed distrust of classroom mathematics may only have extended to what they saw as problems in written lessons and not to a particular discussion of mathematics.

Consistent with the discussion of the occurrence of power statements (P) in exceptional lessons was the *NCTM Standards* identification of student empowerment as a goal for classroom instruction. Students' statements directing classroom lessons gave evidence of the teacher's successful transfer of authority and the students' assumption of responsibility for directing the lesson.

Students' Perceptions of their Questions

The teacher's commitment to student questions and empowerment, coupled with the student's willingness to cooperate, framed a classroom atmosphere conducive to modification of both the IRE pattern and student questions. However, there was little change in the actual count of the type and number of student classroom questions asked throughout the year in traditional whole-class instruction, except during a few lessons that the students did not treat as typical classroom mathematics.

Table 2
Student Estimated Number of Questions Asked During a Lesson

Estimated Number of Questions	0	1	2	3	4	5	10	15	20
Percent of Student Responses	12%	27%	27%	15%	8%	5%	4%	1%	1%
Key Student Responses			Ray Emy Pat	Jane Beth		Fred			

The students were asked to estimate the number of questions that they asked on an average day. Table 2 illustrates the key students' responses and the percent of students who responded with similar estimates. Sixty-one percent of the students thought they asked 2 or more questions per day. That would indicate that most students generally thought that there were a minimum of 60 student questions asked during each lesson. In fact, there were an average of 8 student questions asked in a typical text- or worksheet-based lesson and 24 student questions in an exceptional lesson.

Recall the factors framing students' decision-making processes about questions and the interpretations of teacher questions (see Table 1). These factors may have influenced the student perception of the number of questions that they actually asked during a lesson. In particular, the general inability to justify a particular mathematical process may have lead the majority of students to respond to the teacher's questions with an answer that outwardly appeared to be a statement, when in fact they questioned their solution. Following this sequence of logic, students answering questions with statements, although not stated in standard question structure or intonation, may have felt as though their responses were inquiries.

Weiner (1979) suggests that experiences remembered and retold may be influenced by emotion. Indeed, emotion may intensify the event for student recall and magnify the importance of the event thus ultimately increasing the recalled frequency. However, intense emotion may not be the ultimate guiding factor in the magnification of the classroom event described by the students. In drawing experiences, children who focus on a particular aspect of their pictures or who perceive certain items in their drawings as having the most importance or value, tended to create that aspect in a larger dimension than the entire representation (Herberholz & Herberholz, 1990). This may suggest that, since students were aware of their teacher's concern with their question asking, they themselves "saw" this particular aspect of their classroom behavior as important or of significance and therefore recalled this information with a magnified view.

Additionally, these students had respect and admiration for the teacher and had formed a type of bond with the researcher. From this perspective, students could have intentionally magnified the number of questions they thought they asked to please the researcher or teacher in this project. They were aware the teacher and the researcher thought that talk in mathematics lessons should include student questions and may have wished to help the project out by asking questions.

Questions may also have been so difficult for these students to ask that when they did ask, the event was magnified in their perception. Thus, they may have magnified the number of questions they thought they asked in response to the level of risk they felt. Since they felt very hesitant to ask questions in general, those that they did ask became magnified in their recollection and estimation of their classroom participation.

Students also could have been including the questions that they had during lessons but did not actually ask. The open-ended questionnaire in which this information was gathered asked for the approximate number of questions that students thought they asked, but it was conceivable that students could have read that inquiry as the number of questions they thought about during a whole-class discussion.

This data indicates that students in this study thought they were changing their classroom participation structures and generally increasing their "question asking," even when they actually were not. Students in this study perceived their teacher's attempts to increase their question asking as successful.

Conclusions

Within the structure that was observed in these two classrooms lies both teacher's and students' experience and knowledge about the form questions take. From a student's perspective, their questions contained only genuine requests for necessary information (Walen, 1993b). Yet their questions were observed to serve other purposes: binding arbitration, stall techniques, and community service. The teacher's wish to empower students whenever she could by returning their question to them resulted in an unintentional tacit message to students. The classroom IIR pattern that resulted in sensitivity to teacher's responses contained elements of the students' social interactions. An additional complicating factors were students' views of mathematics as not dependable and their difficulty in justifying mathematical processes: students were unable to evaluate the quality of their question before asking. These two factors made most questions risky and non-algorithmic hypotheses almost non-existent in most structured classroom lessons.

In the two classrooms studied for this research project, the teacher placed emphasis on changing the classroom talk from the traditional to the type recommended by the *NCTM Standards*. Although the teacher was intellectually committed to the direction that the *NCTM Standards* provided, she was also inexperienced in the adjustments required for students to meet these new demands. Both the teacher and students had difficulty in knowing how to modify the existing classroom structure, how to maintain existing changes during problematic episodes, and how to evaluate their progress. This progress, however limited, was exactly what the teacher and students in their everyday classroom lives were capable of accomplishing. The steps taken were small, but they were steps that teacher and students alike took pride. They were individuals in a mathematics reform classroom and that was a matter of pride for teacher and students alike.

Finally, an important aspect of classroom learning is the unique interpretation and construction of knowledge dependent upon an individual student's perspective. This perspective includes cognitive, epistemological, moral, and practical aspects of how the individual perceives the job of being a student.

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