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Communication Theory Offers Insight into Mathematics Teachers' Talk

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This article discusses how communication theory is used to understand the thoughts mathematics teachers employ when creating messages intended for students. According to communication theory, individuals have different premises about the act of communicating, and these thoughts, called message design logics, guide the process of reasoning from goals or intentions to actual messages (O'Keefe, 1988, 1990). Three distinct message design logics have been identified by communication theorists: expressive, conventional, and rhetorical. Depending upon which logic an individual employs, a very different message is said and heard. This theory was used to investigate the message design logics of 15 secondary mathematics teachers. It was found that teachers have varying logics in their message production and, depending upon the logic used, distinct characteristics correspond to different teacher premises for classroom communication.. The logic employed also results in different ways teachers encourage mathematical learning and evaluate classroom interactions.

In the last twenty years, a considerable literature base has been created by mathematics educators that describes effective verbal exchanges for classroom instruction and the critical role the teacher has in that process (Cobb, Wood, & Yackel, 1990, 1993; Cobb, Wood, Yackel, & McNeal, 1992; Cohen & Ball, 1990, 2000; Hiebert et al., 1997). The teacher uses verbal communication to articulate expectations, show care for students, and encourage discussion of specific content knowledge. During instruction, the teacher uses verbal communication to initiate questions and describe tasks in order to elicit, engage, and challenge student thinking. The teacher decides what topics to pursue in depth based on student feedback and content objectives, how to encourage every student to participate, and how to integrate further mathematical connections and representations of the topic.

Research on teaching and learning supports classroom discussions where the teacher focuses on students' mathematical thinking and guides the discussion so the group can reach a consensus on an understanding of the particular mathematical content. However, these interactions have not been typically found in mathematics classrooms (Goos, 1998; Jacobs, Hiebert, Givvin, Hollingsworth, Garnier, & Wearne, 2006; Weiss, Pasley, Smith, Banolower & Heck, 2003). Specifically in the United States, the Third International Mathematics and Science Study (TIMSS, Jacobs et al., 2006) reported that 78% of the topics covered during the eighth grade lessons were procedural, without ideas being explained or developed. Also in that report, 96% of eighth grade teachers stated that they had some awareness of current recommendations for mathematics education and 76% said that they kept up with these recommendations. This inconsistency between research and practice needs more research; the National Research Council (Kilpatrick, Swafford, & Findell, 2001) called this area of research incomplete. Researchers should continue to make visible teachers' decisions, and their consequences for students' learning, as they manage classroom discourse.

Communication theory offers a different approach for mathematics educators to understand classroom interactions. Communication researchers have developed a body of research describing how individuals create and understand verbal messages. They view verbal communication as a strategic type of social interaction where "conversationalists create and modify their individual interpretations of their social world" (Stamp, Vangelists, & Knapp, 1994, p. 194). According to communication theory, message design logics (MDLs) are systematic thoughts about a communication situation that an individual relies on when creating a verbal message (O'Keefe, 1988, 1990). Depending upon the logic used by an individual, a very different message is said and heard. This paper examines how message design logic theory provides insight into secondary mathematics teachers' verbal messages.

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Message Design Logic Theory

Researchers have found evidence for three different message design logics used by leaders in specific communication situations (Hullman, 2004; Lambert & Gillespie, 1994; Lambert, Street, Cegala, Smith, Kurtz & Schofield, 1997; O'Keefe & McCornack, 1987; Peterson & Albrecht, 1996; Street, 1992). These logics are identified as expressive, conventional, and rhetorical and are developmentally ordered. Each has a constellation of related beliefs that describes the individual's purpose for the message, choice of message context, management of the interaction, and evaluation of the interaction.

Expressive Message Design Logic

Individuals employing expressive design logic operate under an assumption that verbal communication is a medium for expressing thoughts and feelings. When these individuals hear or see an event, they respond verbally with their immediate thoughts, conveying a clear and honest reaction. Individuals using this logic believe listeners will understand the message provided that they speak openly, directly, and clearly. The conversation, being organized around immediate reactions, is quite literal, with little distinction between what is objectively and subjectively relevant in the situation (O'Keefe, 1988). If another person in the exchange challenges the communication, the individual will again respond verbally, including some editing of previously stated messages. On average, 22% of participants in message design logic studies employ this type of logic in their verbal communication (Hullman, 2004; Lambert & Gillespie, 1994; Lambert et al., 1997; O'Keefe & McCornack, 1987; Peterson & Albrecht, 1996; Street, 1992). In the mathematics classroom when students ask clarifying questions, a teacher employing expressive design logic reacts by stating his or her immediate thoughts. These thoughts will likely focus on the teacher's thinking, not the student's thinking. As a result, this teacher will tend to simply repeat what was said earlier, attempting to be more clear and organized.

Conventional Message Design Logic

An individual employing conventional message design logic believes communication is a cooperative "game" to be played using conventional rules and procedures. The individual organizes messages for the purpose of achieving a particular response, and expects everyone to play the game by listening to the communication context and inferring the individual's intentions. Communicators who employ conventional message design logic try to say things they believe are appropriate, coherent, and meaningful for the situation. These messages are coherent and meaningful only when all parties involved agree on the same rules and norms. The individual hears and sees the response of others, assesses the response in the context of the situation, and continues the conversation using conventionally defined actions that they feel are appropriate. The individual judges the communication successful when he or she achieves the desired response, provided that everyone agrees on the communication rules and norms. This is the most common message design logic individuals employ in conversations, with studies reporting that 42% to 58% of individuals use the conventional message design logic (Lambert & Gillespie, 1994; O'Keefe & McCornack, 1987; Peterson & Albrecht, 1996).

The mathematics teacher employing conventional design logic will focus on using conventional norms and practices for communication in the mathematics classroom. Upon hearing and evaluating students' responses, the teacher says what is needed to move them in the direction he or she thinks is appropriate. As teachers develop their professional expertise they learn responses they should employ in various situations; this newly developed expertise guides their communication. Unlike the expressive design logic, where responses are immediate, this communication is more purposeful and guided by conventional rules for communicating, though it may not necessarily address the students' needs or questions.

Rhetorical Message Design Logic

Rhetorical message design logic is based on the belief that "communication is the creation and negotiation of social selves and situations" (O'Keefe, 1988, p. 87). The individual employing this message design logic realizes that the intended meanings of his or her messages are not fixed, but are part of the social reality being created with others. Rather than merely being immediate reactions or conventional responses to situations, messages are explicitly designed toward the achievement of goals. Words shared in the exchange are not treated as givens, but as resources that can be called on in transforming the situation towards attaining the desired goal. These communicators use language to transform the situation to be more motivational and to give explicit re-descriptions of the context so that goals are achieved.

Communicators using rhetorical message design logic will also modify their language style to define a

symbolic reality so that listeners can make an acceptable interpretation and be motivated to give an acceptable response. Successful communication is viewed as a smooth and coherent negotiation among all participants towards a desired goal. Although this logic is used by 22% to 32% of adults, researchers have found that individuals typically preferred messages consistent with a rhetorical message design logic (Lambert & Gillespie, 1994; O'Keefe & McCornack, 1987; Peterson & Albrecht, 1996).

Of the three message design logics, rhetorical message design logic seems to best resemble the current literature describing preferred classroom communication (Franke, Kazemi, & Battery, 2007). The rhetorical message design logic emphasizes a dynamic negotiation in communication. Mathematics education literature describes classroom communication where the teacher, as facilitator, focuses on student thinking and encourages dialogue so that students negotiate mathematical understanding. Teachers who use this logic realize that communication is a dynamic negotiation process and that the students' thoughts, the current situation, and the teacher's goals must all be taken into account. They do not respond with prescribed statements, but are more reflective in their interactions with students.

In summary, expressive message design logic is a system of talk that simply reacts to circumstances, whereas conventional message design logic is a system that responds to exigencies with some appropriate preconceived remedy. In conventional message design logic, responses are limited by historically evolved structures. Rhetorical message design logic, on the other hand, draws on a wider range of structures, while containing within it the knowledge of conventional social forms and relations. Further, rather than seeing people and situations as givens in a conventional system of rules or seeing meaning as fixed in messages by their form and context, "meaning is instead treated as a matter of dramaturgical enactment and social negotiation" (O'Keefe, 1988, p. 87). The relation of message and context is reversed in the conventional and the rhetorical view. In the conventional view, context is given and the relevant features of the context anchor meaning, but in the rhetorical view, context is created by the message or the process of communication. Table 1 summarizes the three message design logics.

Message Design Logics of Secondary Mathematics Teachers

Message design logic theory provides a framework for studying classroom interactions. Consider the following description of classroom communication summarized from the National Council of Teachers of Mathematics' *Principles and Standards for School Mathematics* (NCTM, 2000):

> Students should engage in conversations in which mathematical ideas are explored from multiple perspectives. They should participate in discussions where they are expected to justify solutions—especially in the face of disagreement. This will allow them to gain better mathematical understanding and develop the ability to acquire and recognize conventional mathematical styles of dialogue and argument. Through the grades, their arguments should become more complete and should draw directly on the shared knowledge in the classroom. The role of the teacher is to support classroom discourse by building a community where students feel free to express their ideas. (pp. 60 – 61)

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Table 1

Characteristics of Message Design Logics

	Expressive	Conventional	Rhetorical
Fundamental Premise	Verbal communication is a medium for expressing thoughts and feelings.	Verbal communication is a game played cooperatively by social rules.	Verbal communication is for the creation and negotiation of social selves and situations.
Key Message Function	Self-expression	Secure desired response	Negotiate social consensus
Message/Context Relationship	Little attention to context	Action and meaning determined by context	Communication process creates context
Method of Managing the Interactions with Other(s)	Editing	Politeness forms	Context redefinition
Evaluation of Communication	Expressive clarity, openness and honesty, unimpeded signaling	Appropriateness, control of resources, cooperativeness	Flexibility, symbolic sophistication, depth of interpretation.

The teacher's role in this communication is to create the opportunity for students to talk and share their ideas. From the message design logic perspective, the emphasis is not on the teacher being clear and organized in presenting the mathematics, nor on securing a desired response from students. Instead the focus is to allow a dynamic conversation to take place where negotiations and consensus by all parties is the desired outcome; this idea is consistent with rhetorical message design logic.

The present study was designed to investigate message design logics of secondary mathematics teachers. Because message design logic theory informs us that individuals hear and say different messages depending upon which message design logic they use, this could be an informative perspective for mathematics educators who are trying to better understand the verbal communication practices in mathematics classrooms. In particular, this study used the message design logic framework to identify a) the fundamental purpose for secondary mathematics teachers' verbal messages to students, b) the key reasons teachers gave for their verbal messages, c) the primary ways secondary mathematics teachers account for students and content in their messages, and d) the perceived success of teachers' verbal messages.

Methods

Fifteen secondary mathematics teachers participated in this study. They were purposefully chosen (Patton, 1990) to reflect a range in experience, school setting (urban and suburban), and education. In interviews, teachers were asked to 1) provide a sample verbal message to address two hypothetical classroom vignettes, 2) recollect two classroom situations where they felt their verbal communication with students was successful and two situations where they felt it was not and 3) provide general information about their experiences with classroom verbal communication and 4) discuss their development of verbal communication skills.

The first part of the interview, responding to the written hypothetical vignettes, was consistent with other message design logic studies. The vignettes in this study were designed with the guidance of mathematics educators, previous message design logic studies (Lambert & Gillespie, 1994; O'Keefe & McCornack, 1987; Peterson & Albrecht, 1996), and a communication professor who has formally studied message design logics (Kline, 1984, 1988, 1991; Kline, Hennan-Floyd & Farnell, 1990). The vignettes needed to contain three key features in order to elicit a variety of responses and determine the message design logic being used by the teacher. First, there is a lack of conformity in the expected response to the situation, allowing salient beliefs from the past that may not particularly be relevant for dealing with the present situation to be accented. Second, actions or processes are included that could be subject to renegotiation but that are relevant to the current situation. Third, the subject is assigned an authoritative role in the group. This last criterion was easily met in this study, because teachers are assumed to be the leaders of classroom instruction. Factors relative to the other two criteria were incorporated into the vignettes, by embedding two to four problem situations that require teachers make decisions about curriculum and instruction.

This paper focuses on the first vignette, where an algebra class is working on the following open-ended problem on the board: 'If the value of $-7abc^2$ is negative, what do you know about the signs (positive or negative) of a, b, and c?' While the students begin working, the teacher walks around monitoring their work and checking homework. The teacher notices that students are struggling with the problem as a number of them had not completed the homework assignment and some were socializing. (See Appendix A for vignette.)

Teachers were asked to state whether they thought the given vignette was realistic, and to provide a sample response message for the vignette. Though in previous message design logic studies the participants were asked to give their response in writing, in this study the response was audio-taped in order to use a cued-recall procedure (Waldron & Applegate, 1994; Waldron & Cegala, 1992). This procedure entails playing back the response and stopping intermittently to get the participant to share thoughts that are relevant to the specific statements. (See Appendix A for interview protocol.) A member check was conducted following each interview. Teachers were supplied with their sample messages and reasons for each message, their positive and negative classroom communication experience, along with general information provided in the interview. After all member-check documents were validated, each message was coded separately by two researchers as reflecting either an expressive, conventional, or rhetorical message design logic; there was 100% agreement between the two coders.

Findings

All three message design logics were found to exist amongst the secondary mathematics teachers. Twenty

percent of the messages were coded as employing an expressive design logic, 53% conventional, and 26% rhetorical. Sample messages given in response to the first vignette representing each message design logic follow.

Mathematics Teachers Using an Expressive Design Logic

Twenty percent of the teacher responses provided for the above vignette were coded as expressive. These messages were characteristically a set of statements in reaction to the situation that often included observations by the teacher that were irrelevant points to solve the immediate mathematical tasks. Here is an example of one such response.

> Folks, we need to get on task here, I need everyone working on this problem. That's important because math is not a spectator sport, you just can't listen to me talk and expect to understand it. Now, get to work so we can get going with this lesson. (If students continue to be off task then I'll tell them I'm going to grade this problem.)

This message was a reaction to the students' off-task behavior. The teacher said the first idea that comes to mind, with little attempt to reorganize or address the students' understanding of the mathematics. There was some irrelevant information in the message about mathematics not being a spectator sport and there were consequences for students who continued not to work on the problem.

The teachers who used this message design logic seemed to have a genuine desire to get students to learn. They designed their messages to guarantee a certain responses, but these messages were predominantly past-oriented, incoherent, and might have failed to engage the immediate mathematical problem at hand. In summary, these teachers used their messages to express their immediate reaction to the current situation.

Mathematics Teachers Using a Conventional Design Logic

Conventional message design logic was employed in 53% of the messages. These messages focused on an appropriate action in the current situation in order to get students engaged with the mathematics. The teacher's main purpose was to secure a desired response from the students, manage the situation, and encourage student cooperation. The context of the message was centered on the action, meaning, and justification of the students' response. A sample of a conventional message is:

> OK class, there seems to be some confusion with the problem. Let's work it out together and we'll talk about the thinking I am asking you to do and why that might be valuable. (After working on the problem together) The problem involved using some critical thinking which is an important part of mathematics. Looks to me like we need to think about and work out more problems like this. (Make up several other problems that are similar.)

When these teachers were asked why they chose to say this message, responses were consistent with O'Keefe's (1988) interpretation: "Either the speaker said this because he or she wants X and saying this is a normal way to obtain X in this situation; or the speaker is responding to prior message M, and the relevant response to M" (p. 87). In summary, the speaker said what was believed to be appropriate to accomplish the intended purposes. When one of the teachers was asked to clarify why he gave a message that was coded as conventional design logic, he stated,

> I want them to think about the logic, the problem solving; it's going through a situation where something is given to you, here's a problem, now what do you do, and they have to realistically think through it, think about what are the things I need in order to solve this problem, do I need to converse with someone else about it, do I need to get input, do I not, do I have the material in front of me, what are my resources, you know, there are three different variables here and so I go through that with them, I say 'OK those are the kind of things you need to be thinking about in this'. And then after that, then they start to understand.

The teachers who used this message design logic also expressed a genuine desire to encourage student learning. They talked about saying what needed to be said in order to accomplish specific learning goals. The teachers, not the students, defined the direction of classroom discussion and activity. These teachers assumed that they knew what the students needed to hear to move students closer to the desired outcome.

Mathematics Teachers Using a Rhetorical Message Design Logic

Rhetorical message design logic was employed in 26% of the messages. These messages allowed for student input, setting the stage for negotiation. The aim of the verbal communication was to build a social consensus. The teacher tried to manage the situation and move the communication strategically towards a desired context. An example of a message employing rhetorical message design logic is:

> (Moves to front of class, and asks for everyone's attention.) "I'm noticing that there is something about this problem that is causing confusion for some of you. Take a minute and write down at least one thing that confuses you, or the rest of you write down at least one key thought that helped you get started on it. (Listen to responses and depending upon what was said would determine what I do next.)

The teachers who employed this design logic in their message were cognizant of the social negotiation. For example, one teacher described the reasoning behind her message as follows:

> I have some ideas about what's going on in this situation, but it's always good to get the students' input first, you know, it could be something I haven't thought of at the time. I don't just want to assume I have all the facts.

Rhetorical message producers placed importance on harmony and consensus. They tended to ignore power and resource control as a means in conflict resolution. They persistently underestimated the force of social convention and routine, and overestimated individuality and creativity. (O'Keefe, 1988). This was also evident when these teachers clarified the reasoning for their messages. One teacher said,

> Students should be given a voice in the classroom, it's so easy to answer and speak for them and move on, when in fact they have a lot to say and contribute, and if we just listen, we learn a lot from them.

These messages were neither a reaction to some prior condition nor a taken-for-granted feature of the classroom. Rather than being a conventional response to some prior state of affairs, they were forward-looking and goal-connected.

Discussion

The main finding of this study is that mathematics teachers have varying knowledge and beliefs about verbal communication and these seem to influence what teachers hear and say when they talk to students. This is a notion to consider as mathematics educators try to understand classroom discourse better. When mathematics teachers have the common goal of engaging students in learning mathematical content, message design logics provide an explanation for the different paths a teacher's verbal message can take towards achieving this goal. In particular, these logics help explain the possible thoughts teachers use as they communicate with students. Because this study found that all three message design logics could be identified in secondary mathematics teachers' verbal messages, it is natural to consider how these message design logics might influence classroom interactions.

Message Design Logics and Classroom Interactions

A teacher employing expressive design logic generally creates messages in response to what is heard and seen in the current situation. The teacher responds with the thoughts that come to mind based on what is happening at that moment. A figure representing this situation is shown below. (See Figure 1.) Even though the classroom interaction includes student talk, the diagram is focused on the teacher's verbal message and the space the teacher provides for students to interact in the discussion. Students' mathematical learning may be the teacher's desired outcome, but the verbal path towards that learning is viewed as more random. The random arrows represent the messages that are expressions of the teacher's initial thoughts. The path from teacher message to desired learning outcome is implicit, as indicated by the dashed line. The space available for students to interact in the discussion is also indicated by the dashed rectangle.

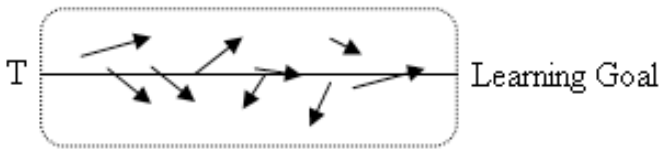

Figure 1. An illustration of expressive design logic.

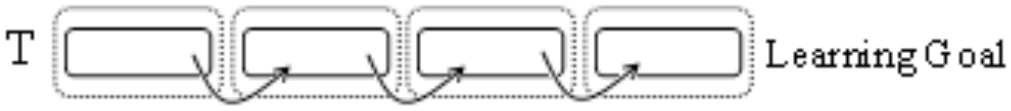

Figure 2. An illustration of conventional design logic.

The teacher who employs conventional design logic, where the verbal exchange is more controlled and fixed, uses thoughts that move students one step closer to the goal of mathematical learning. The figure below represents this classroom interaction. (See Figure 2.) The teacher focuses his or her message on a piece of information, determining the appropriateness of responses to the next piece of information. Each message is an effort to move the students closer to the desired learning goal. The space for student interaction can be narrow or broad depending upon the teacher's intention for that piece of information. The teacher's message encompasses elements that relate to the desired outcome for the current piece of information.

For a teacher who employs rhetorical message design logic during classroom instruction, the goal is to create verbal messages that allow students to have space to discuss their thinking, and allow the teacher to redirect the conversation when needed in order to achieve mathematical learning goals. (See Figure 3.) With these goals in mind, the teacher creates his or her verbal messages. The teacher begins the interaction with a message to open the space for negotiation. Focusing on the learning goal, the teacher creates messages to collect everyone's thoughts and directs the student interactions as needed.

In summary, the theory of message design logics provides mathematics teacher educators a way to explain teachers' knowledge and beliefs about communication: what they believe is important to say and why it is important. These different beliefs influence the message design logic used, thereby impacting how the message is stated and heard by the teacher. This perspective can inform mathematics teacher educators' thinking about teachers' classroom communication.

Further Research Using Message Design Logic Theory

Because this study established that different message design logics do exist in secondary mathematics teachers' communication, this theory is being used to study interactions in the classroom setting. For a study in progress, teachers have agreed to have their classroom interactions audio recorded and follow up with an interview similar to the protocol, shown in the Appendix. This investigation aims to identify how the teacher verbally addresses the challenges that arise in the classroom. Other issues being considered are the consistency of a teacher's message design logic across conversations, and the identification of the influence of contextual factors. Preliminary findings indicate that there is a consistent message design logic that a teacher uses during classroom conversations.

A second study in progress is investigating how preservice teachers develop their logical reasoning for classroom verbal interactions while participating in their teacher preparation program. Data has been collected throughout the preservice teachers' university experiences during related coursework, field experiences, and student teaching. This data include an initial survey, written responses to classroom episodes, a self-evaluation of classroom discussion, student teaching evaluations, and interviews at the conclusion of their program. In these two studies described above, message design logic theory continues to provide an effective lens for studying teacher communication.

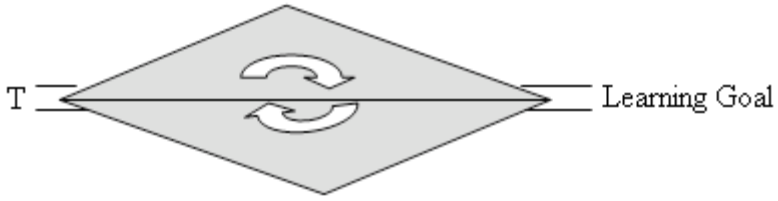

Figure 3. An illustration of rhetorical message design logic.

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Appendix: Interview Documentation

A classroom vignette and a set of semi-structured interview questions were among the documentation taken to each interview. An abridged interview outline focusing on the cued recall questions and general questions is shown below. It should be noted the interview outline here is the one used during the study discussed in the article, but changes have been made in subsequent studies to reduce the amount of time needed to study each individual and allow for a greater number of participants. For example, the evaluation of another teacher's classroom transcript has been omitted because this data focused less on the verbal interaction and more on the environmental and situational factors.

I. Introduction, Expectations, Info Sheet
II. Vignette 1/Vignette 2:

- Directions

Here is a hypothetical classroom situation. Please take a minute to read this and think about how you would respond. When you are ready, tell me exactly what you would say in this situation to the student and/or students.

- How realistic is this situation likely to happen in a mathematics classroom?

- Cued-Recall Task

Now we are going to play back pieces of your response OR Now I am going to review some of the things you said. Try to remember what you were thinking at that time. You are going to be asked to answer three questions the best you can about your thoughts during this period of the response. If you cannot remember or are not sure, just indicate so, do not try to guess.

1) What were your reasons for saying that?
2) Were you thinking about other things that you might do or say in the near future or later in the conversation?
3) Was there something you thought about saying but didn't? Why?

- After Cued-Recall

1) What would you like your students to think about/do/say after hearing your message?
2) What do you believe students thought were your reasons for saying that?
3) In summary, what do you believe are the most important ideas needing responded to in this situation?
4) What do you think will happen next?

- Critique

Participant was given a transcript of an actual lesson where the teacher employs an expressive design logic. That is, the teacher in the lesson just reacts to the questions being asked, focusing on one student at a time. Participants were asked to evaluate the transcript, providing examples from their classroom experiences.

- General communication questions

We have been talking about particular messages you would create in the classroom, based on specific situations. Now I'd like to step back and ask some general questions about this.

1) On a scale of 1 – 5, one being lowest and five highest, how would you rank your classroom communication and tell me why.
2) Can you remember a time when it was higher than this number and describe that situation to me?
3) What made that situation "better"?
4) Can you remember a time when it was lower than this number and describe that situation to me?
5) What made that situation "worse"?
6) What is your role in classroom communication?
7) What is the students' role?
8) What factors do you think effect your verbal communication in the classroom?

If extended message stated, use cued-recall

Now we are going to play back pieces of your response OR Now I am going to review some of the things you said. Try to remember what you were thinking at that time. You are going to be asked to answer three questions the best you can about your thoughts during this period of the response. If you cannot remember or are not sure, just indicate so, do not try to guess.

1) What were your reasons for saying that?
2) What would you like your students to think about/do/say after hearing your message?
3) What do you believe students thought were your reasons for saying that?

Vignette #1: The bell has rung, you asked students to get out last night's homework and while you go around and check to see if they have it done, students are to work on a problem you've written on the board to start the day's lesson.

If the value of $-7abc^2$ is negative, what do you know about the signs (positive or negative) of a, b, and c?

As you walk around, you notice there are many of them who had not completed the homework assignment, and even more are taking this time to socialize instead of work on the problem. You remind them to work on the board problem. Some students begin working on the problem, others just sit there, and Max, a student on the other side of the room says "Why do we have to do this?" Another student, sitting right next to you adds, "This problem is stupid."

Describe exactly what you would say to the student(s).