CHAPTER 1: BACKGROUND, RATIONALE, AND PURPOSE

This dissertation documents the extent to which middle school students engage in small-group sense-making discussion, and also identifies those factors which provide support (or not) for small-group sense-making discussion.

Background

For the past few decades, a good deal of attention has been paid to how students construct conceptual and procedural understandings of science. As a result, a number of theories have become increasingly refined to explain how students construct and modify their knowledge structures. *Constructivism*, for instance, a modern theory of knowledge, holds that individuals actively construct subjective understandings of the physical world based on their personal experiences (von Glasersfeld, 1984). From this paradigm, conceptual development occurs when people become dissatisfied with their existing conceptions (a state known as "disequilibration"; see Piaget 1952, 1969) and feel the need to modify their understanding of the world. Another theory -- *information processing* , a theory of cognition -- uses the "mind-as-computer" metaphor to explain how cognition proceeds. From this perspective, learning is the process of perceiving sensory inputs (i.e., new information), performing mental operations on this new information in working memory, and, finally, modifying existing knowledge structures in long-term memory (Atkinson & Shiffrin, 1968).

Clearly, these two widely-held theories take a cognitive approach to the learning process -- meaning that, from these perspectives, the factors most

relevant to learning are those factors which deal directly with knowledge and thought processes. Consequently, when considering the best ways to educate their students, teachers who fall into the "constructivist" or "information processing" paradigms are likely to focus on one or more of the following cognitive factors: the form and content of existing knowledge structures, the development of new knowledge structures, metacognition (i.e., awareness of one's own mental activity), and so forth. For example, the teacher who bases her teaching on the theory of constructivism focuses on structuring learning activities that a) help students become aware of their prior knowledge and the ways in which this knowledge develops over time (Hewson & Thorley, 1990), and b) surprise or perplex students in order to have them experience dissatisfaction with this knowledge (Dykstra, Boyle, & Monarch, 1992). Similarly, the instructor who bases his instruction on the "information processing" paradigm is primarily concerned with such matters as cognitive efficiency (Reif & Larkin, 1991) and the differences between the knowledge structures and thought processes of experts and novices (Chi, Feltovich, & Glaser, 1981; Larkin, McDermott, Simon, & Simon, 1980).

Recently, however, researchers have come to believe that these sorts of cognitive perspectives need to be modified to include other factors in the learning environment. Strike and Posner (1992), for instance, argue that their well-known outline of the conditions necessary for conceptual change (dissatisfaction with existing conceptions, followed by the introduction of a new theory which is plausible, intelligible and fruitful; see Posner, Strike, Hewson, & Hertzog, 1982) should be expanded to include institutional and social

sources of motivation and goals. Pintrich, Marx, and Boyle (1993) use the word ***cold*** to describe current theories of student learning (i.e., those concerned solely with cognitive factors); their suggestion is that researchers should shift their sights and focus -- in their new, ***hot*** theories of cognition -- on the roles of context and motivation in the learning process.

An important justification for expanding our focus to include social and contextual factors in the learning environment is that, in part, learning is just that: a social, contextually-ground process. From a *sociocultural* perspective, for example, the behaviors, thoughts, and actions of students are recognized as being influenced by the expectations, traditions, and values of the classroom community (i.e., the classroom community's norms and values; see Cobb, Wood, & Yackel, 1993) . For instance, students are often reticent to speak in classrooms where they cannot trust their teacher to show serious interest in their ideas and questions (Mitchell, 1992). Another key aspect of the sociocultural perspective on learning is Vygotsky's idea that learners develop by internalizing the guidance of others (Griffin & Cole, 1984; Vygotsky, 1986, 1987). Vygotsky argues that, through social interaction, people move from needing guidance to accomplish a given task to eventually (after internalizing this guidance) being able to accomplish the task themselves. As applied to the classroom, the idea is that classroom discussions and joint problem-solving sessions help students internalize peer- and adult-modeled concepts and procedures -- at which point the tasks that previously required guidance (e.g., scientific reasoning, problem-solving, setting up a scientific experiment) can now be done independently. In short,

Vygotsky's notion of guidance is crucial as a direct connection between students' individual learning and the teacher-student and student-student social interactions that commonly occur in the classroom.

Rationale

Research topic. With guidance playing such a key role in the learning process -- and especially in the wake of the National Research Council's (1996) recommendation that science education should be grounded in collaborative, inquiry-based activity -- it is therefore logical to turn to small-group student discourse (conversation) for insights into science learning in today's classrooms. For, as related to the construction of new scientific understanding, it is in these groups that students have the opportunity to test each other's experimental predictions, elaborate on each other's ideas, and engage in other types of discourse which lay the groundwork for establishing the meaning of scientific concepts.

And, while educators would love for these sorts of sense-making discussions to be commonplace in their classrooms, it is clear that these discussions aren't likely to occur without support from the teacher and the school curriculum (Johnson & Johnson, 1994). Ultimately, the idea is that educators will be able to create formal and informal learning environments that are conducive to small-group sense-making discussions once they become more aware of the many factors affecting this special brand of discourse. This is why the goal of the present study was to identify those factors having the most influence on middle school students' small-group sense-making discussions.

Research Methods. This study was based on quantitative and qualitative analyses of student conversations recorded in two middle school inquiry-based science classrooms. Allowing students to work in the classroom was important because it isn't clear that the results from investigations in an artificial environment (e.g., having student participants engage in activities after school, or outside the classroom) always apply to "real-life" classrooms. In general, it has been found that the use of activity-driven conversations -- whether they be conducted in museums (Borun, Chambers, & Cleghorn, 1996; Diamond, 1986), classrooms (diSessa, Hammer, Sherin, & Kolpakowski, 1991; Hammer, 1995), or other educational contexts -- lend themselves nicely to careful, descriptive analysis of student scientific discussion.

Research Questions

In alignment with my interest in studying the factors affecting students' sense-making discussion, this study contributes to the research in science education by answering the following research questions. In particular, the context for this study was middle school students' discussions as they worked on force- and motion-based science activities in small groups.

1. How can we classify students' sense-making statements?

To study students' sense-making discussion, one must be able to identify and categorize it when it appears.

In this study, I constructed my own framework for verbal sense-making. This framework evolved from a framework for nonverbal sense-making known as *comprehension activity* (outlined in Chapter 2).

2. To what extent do students engage in sense-making discussion?

It was of interest to determine to what extent certain students would engage in some, none, or a good deal of sense-making discussion in those portions of the curriculum where sense-making discussion is expected.

3. Which factors provide support for students' sense-making discussion?

The final purpose was to identify those personal, task-related, group-related (i.e., social), and contextual factors providing the greatest support for -- or hindrance to -- students' small-group sense-making discussions. Personal factors are those relatively stable intrinsic factors that one would normally associate with individual students (e.g., learning and performance goals, interpersonal skills, and subject matter interest). Task-related factors reflect the various ways that the educational task drives group discussion, via science content, task goals, prompts in the curricular materials, and the degree to which the task is intrinsically motivating. Group-related factors, such as group norms, social roles, and leadership styles, describe the ways that social interactions, group norms, and student leadership affect the group's sense-making conversation. Contextual factors include the physical, organizational, and cultural aspects of the learning environment (e.g., classroom norms, the physical layout of the classroom, and the role of the teacher).

Overview of Upcoming Chapters

In Chapter 2, I do two things: (1) provide the conceptual frameworks for comprehension activity (nonverbal sense-making), discourse, and collaboration, including their relationship to the learning process, and (2) summarize the personal, task, group, and contextual factors that were likely to affect sense-making discussion in this study.

In Chapter 3, I outline my methods of analysis; in particular, I describe the methods used to:

- establish the extent of students' SMD in an inquiry-based middle school science curriculum;
- determine significant differences in SMD between group, students, and curriculum areas; and
- identify the factors that explained these significant differences in sense-making.

In Chapter 4, I chronicle how, after careful analysis of the small-group discussions in this study, I modified the *comprehension activity* framework for nonverbal sense-making in order to arrive at my own framework for SMD. Included are examples of the six different components of SMD that comprise my framework.

In Chapter 5, I document the extent of students' sense-making discussions and summarize significant differences in sense-making across students, groups, and areas of the curriculum. In Chapter 6, I then analyze to what extent the list of factors drawn from prior research (as outlined in Chapter

2) contributed to these significant differences in SMD, and also to what extent any additional factors contributed to these differences.

Finally, in Chapter 7, I comment on (a) the implications of this study for classroom practice in inquiry-based science classrooms, and (b) the type of future research that could be fruitful in helping students engage in small-group discussion in order to better understand the principles of physical science.