

Teacher-student interactions in SIMMS and non-SIMMS mathematics classrooms
by Birdeena Crandall Dapples

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Education
Montana State University
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Abstract:
The Systemic Initiative for Montana Mathematics and Science (SIMMS) project is creating a program for grades 9-12 which consists of integrated mathematical curricular materials, alternative forms of assessment, and constructivist pedagogical methods. One of the teacher's roles is that of a facilitator of learning with the students taking more responsibility for their learning. The facilitator role represents a paradigm shift for many mathematics teachers. The study documented teacher-student interactions of mathematics teachers implementing the SIMMS curriculum and its accompanying constructivist methodology. The study examined the teacher-student interactions of four SIMMS-prepared teachers in their SIMMS and non-SIMMS classrooms over a four-month period during the first year of the experimental program. The findings were as varied as the individual personalities of the teachers, but there was a decided increase in the use of student-centered interactions in the SIMMS classrooms as compared to the non-SIMMS classrooms. However, the majority of the classroom interactions in both types of classrooms were still teacher-centered. Curricular materials based on constructivist ideas incorporating cooperative learning groups help encourage the use of student-centered teaching. However, extended professional development experiences are essential to help teachers translate the recommended constructivist methodology into appropriate teacher-student interactions.

TEACHER-STUDENT INTERACTIONS IN SIMMS AND NON-SIMMS MATHEMATICS CLASSROOMS

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A thesis submitted in partial fulfillment
of the requirements for the degree

of

Doctor of Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

January 1994

D378
D2395

APPROVAL

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Date January 18, 1994

"Mathematics teaching consists primarily of the mathematical interactions between a teacher and children" (Steffe & Killion, 1986, p. 207).

ACKNOWLEDGMENTS

I wish to thank my committee members for their support and assistance in this project. In particular, I would like to thank Dr. Glenn Allinger, who was always ready to listen to my problems. His use of student-centered teaching helped me to "construct" my understanding of professional development and teacher-student interactions. I appreciate Dr. Elisabeth Charron's assistance in the area of qualitative research and her willingness to take over as co-chair of my committee in "mid-stream."

The SIMMS project personnel, from the directors to the secretaries, have been very supportive and helpful with this project and I greatly appreciate their cooperation. I owe a debt of gratitude to the four teachers who allowed me to observe their classes as they pre-piloted new curricular materials.

I also wish to thank my daughter, Cathryn, for reading many versions of this paper and offering gentle constructive criticism.

This material is based upon work supported by the National Science Foundation under Cooperative Agreement No. TPE 9150055. The Government has certain rights in this material. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation.

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ABSTRACT

The Systemic Initiative for Montana Mathematics and Science (SIMMS) project is creating a program for grades 9-12 which consists of integrated mathematical curricular materials, alternative forms of assessment, and constructivist pedagogical methods. One of the teacher's roles is that of a facilitator of learning with the students taking more responsibility for their learning. The facilitator role represents a paradigm shift for many mathematics teachers. The study documented teacher-student interactions of mathematics teachers implementing the SIMMS curriculum and its accompanying constructivist methodology. The study examined the teacher-student interactions of four SIMMS-prepared teachers in their SIMMS and non-SIMMS classrooms over a four-month period during the first year of the experimental program. The findings were as varied as the individual personalities of the teachers, but there was a decided increase in the use of student-centered interactions in the SIMMS classrooms as compared to the non-SIMMS classrooms. However, the majority of the classroom interactions in both types of classrooms were still teacher-centered. Curricular materials based on constructivist ideas incorporating cooperative learning groups help encourage the use of student-centered teaching. However, extended professional development experiences are essential to help teachers translate the recommended constructivist methodology into appropriate teacher-student interactions.

OVERVIEW OF STUDY

Introduction

Two major contributors to a student's success in school are the contexts in which the school subjects are taught and the teacher-student interactions within the classroom (Chismar, 1985; Mehan, 1982; Renninger & Winegar, 1985; Troisi, 1983). Currently some mathematics curricular reform projects are trying to address the context issue by writing materials that focus on applications of mathematics to the student's world. However, unless these projects also address the other main contributor to student success, classroom interactions, they will not get a complete picture of the impact of their reform. Both the context of the subject matter and the teacher-student interactions affect student success and consequently the success of the reform.

The Systemic Initiative for Montana Mathematics and Science (SIMMS) is funded by the National Science Foundation (NSF) and the State of Montana and administered by the Montana Council of Teachers of Mathematics (MCTM). SIMMS is a curricular reform project which is creating an integrated mathematics program intended for all students in grades 9-12. There is strong support for this type of program across the nation as revealed in a 1989 study by the Integrated Mathematics Project (IMP) under the

sponsorship of the Exxon Corporation (Beal, Dolan, Lott, & Smith, 1989). SIMMS is attempting to implement the concept of integrated mathematics which emerged from the IMP study. A key feature of the IMP model curriculum is the use of applications from the "real-world" as a context for the mathematics. There is also a strong emphasis on enhancing the students' problem-solving skills. For a more complete description of the IMP model, see page 9.

A curricular focus on problem-solving skills will necessitate a classroom environment which encourages students to take an active part in making sense of a problem-solving situation for themselves, rather than simply memorizing formulas. The National Council of Teachers of Mathematics (NCTM) and the National Research Council (NRC) encourage teachers to interact with their students in ways that actively involve the students in the learning process (National Council of Teachers of Mathematics [NCTM], 1989 &1991; National Research Council [NRC], 1989). The NCTM Curriculum & Evaluation Standards for School Mathematics (1989) advocates that teachers adopt a "constructive, active view of the learning process" (p. 10). The NRC report Everybody Counts says that

> educational research offers compelling evidence that students learn mathematics well only when they construct their own mathematical understanding. . . . This happens most readily when students work in groups, engage in discussion, make presentations, and

> in other ways take charge of their own learning. (NRC, 1989, p. 58)

Unfortunately, the typical mathematics classroom in this country does not reflect this constructivist paradigm. The scene, which is played out in numerous classrooms each day, is one of students sitting in desks aligned in neat rows. Normally, the teacher shows the students how to do some of the more difficult problems from the previous day's assignment, lectures on the new material for the day, and assigns problems from the textbook at the end of the day's lesson. Students who have been taught in this manner for ten or twelve years are often unable to apply the mathematics they have learned. They also lack the problem solving and communication skills that today's business community desires or the skills necessary to be informed consumers and citizens (Montana Science Education Board [MSEB], 1991; NRC, 1989).

In contrast, a mathematics classroom which implements the SIMMS integrated mathematics project is envisioned as one in which

- the mathematics content is integrated;
- the curricular materials help the students to construct their own meanings out of mathematical situations through self-directing activities;
- the teacher is a facilitator of learning, not only a purveyor of knowledge;
- appropriate technology is utilized;
- a variety of instructional formats are used including cooperative learning groups and individual projects; and

- a variety of alternative assessment methods are used including open ended questions. (Systemic Initiative for Montana Mathematics and Science [SIMMS], 1992a, 1993)

This type of classroom environment may be very different from the one to which many mathematics teachers are accustomed. The SIMMS project recognizes that teachers may need to make a shift in their teaching practice "away from an 'instrumentalist' practice, where computational procedures are ends in themselves, toward a 'constructivist' practice rooted in real world applications" (SIMMS, 1992a, p. 5).

Statement of Problem

Teacher-student interactions are one way teachers put their philosophies of teaching and learning into practice. Many research studies have reported on the strong influence of various types of teacher-student interactions on students' success in school (Chismar, 1985; Mehan, 1982; Renninger, 1985; Samuelowicz & Bain, 1992; Troisi, 1983). These studies noted that while students participate in classroom interactions, the teacher signals "the type and amount of participation permitted" (Chismar, 1985, p. 23). Consequently, those classroom interactions which involved the teacher were the primary interest of this study.

The study investigated the teacher-student interactions in the SIMMS and non-SIMMS classrooms of teachers who pre-piloted

the SIMMS ninth grade program. This researcher looked for patterns of teacher-student interactions across a teacher's SIMMS and non-SIMMS classrooms or differences in interactions between a teacher's SIMMS and non-SIMMS classrooms. Of special interest were interactions as listed in the description of a facilitator of learning (see page 8).

The NCTM Curriculum Standards (1989) described recommended instructional practices for 9-12 mathematics classes in terms of teacher-student interactions. Teachers were advised to involve students in constructing mathematical ideas, ask questions that promote student interaction, use a variety of instructional formats, and have students communicate mathematical ideas orally and in writing (NCTM, 1989). The intent of the SIMMS project was to design curricular materials which enabled students to construct their own mathematical understandings from self-directed learning situations, thereby shifting the teacher's role to one in which the type of interactions described by the NCTM Standards are used (SIMMS, 1992a).

Several Montana high schools were chosen to field test the first modules of the SIMMS program, in their draft form. In order to acquaint the teachers who were to be involved in the field test with the curricular materials, technology, and recommended pedagogy, a six-week summer institute was held during the summer of 1992, prior to the pre-piloting year. The institute gave the teachers an opportunity to study the methodology advocated by

the SIMMS project, experience SIMMS curricular materials (in draft form), learn to use recommended technology, discuss alternative pedagogy, and experiment with instructional situations. Some of the institute teachers were chosen to pre-pilot the full set of modules for the ninth grade (Level One) while others pre-piloted only three or four modules.

Other SIMMS studies looked at student achievement. This study documented the type and frequency of teacher-student interactions in both SIMMS and non-SIMMS classrooms. The documentation of these interactions in the SIMMS classrooms was intended to assist the SIMMS project in interpreting student achievement results, especially since a set of numerical scores at the end of the school year does not give a complete picture of curricular change. The identification of patterns of teacher-student interactions was intended to help document how the material was taught and whether the proposed constructivist methodology was implemented. A comparison of teacher-student interaction patterns between a teacher's SIMMS and non-SIMMS classes is also intended to help the SIMMS Project assess the effect of their curricular materials on teaching practices.

Timeline of Study

April 1992

Contacted teachers for pre-institute observations and permission to include them in the study.

May 1992

Conducted pre-institute classroom observations and teacher interviews with nine institute participants.

June - July 1992

Selected set of five teachers, from original nine, to participate in study (see page 26).

Selected methods of data collection: Flanders Interaction Coding Schema, classroom observations, and personal interviews.

September 1992

Conducted preliminary visits to study teachers.

Refined data collection techniques (see page 32).

October 1992

Made first visit to study teachers. Observed two consecutive days in one SIMMS and one non-SIMMS class. Conducted first interview.

November-December 1992

Made second visit to study teachers - same data collection procedures.

January 1993

Made third visit to study teachers - same data collection procedures.

February - March 1993

Transcribed classroom and interview audiotapes.

April - June 1993

Finalized code list for interactions.

Analyzed code summaries, field notes and interview statements.

July 1993

Reviewed findings with study teachers.

Definitions

Constructivism: An epistemology which describes knowledge as a personal construction based on a person's experience (Ernest, 1989; Noddings, 1990; von Glasersfeld, 1990).

Facilitator of learning: An instructor who

- uses a variety of instructional situations;
- assists students in organizing cooperative learning groups;
- has students do class presentations;
- demonstrates a positive attitude toward mathematics;
- demonstrates a positive attitude toward students, regardless of gender or ethnic origin;
- demonstrates use of appropriate technology;

- encourages students to use appropriate technology;
- requires students to express mathematical ideas in written and oral form;
- uses alternative assessment tools;
- encourages discussion among students about problems and possible solutions;
- attempts to understand the student's rationale for his or her work;
- brings up evidence that conflicts with students' interpretation, so they can re-examine their thinking;
- asks process-oriented questions;
- asks open-ended questions;
- asks judgment questions;
- moderates class discussions on student generated ideas;
- helps students to rely on themselves to determine whether a solution is mathematically correct; and
- creates a classroom environment in which students are encouraged to take risks. (NCTM, 1991 &1989; Peterson, 1988; Rogers, 1969; SIMMS, 1993 &1992a)

Integrated Mathematics Project Concept: An integrated mathematics program for all students

- consists of topics chosen from a wide variety of mathematical fields and blends those topics to emphasize the connections and unity among those fields;

- emphasizes the relationships among topics within mathematics as well as between mathematics and other disciplines;
- each year, includes those topics at levels appropriate to students' abilities;
- is problem-centered and application-based;
- emphasizes problem-solving and mathematical reasoning;
- provides multiple contexts for students to learn mathematical reasoning;
- provides continual reinforcement of concepts through successively expanding treatments of those concepts; and
- makes use of appropriate technology. (Beal et al., 1989, p. 4)

SIMMS classroom: A high school mathematics classroom in which

- SIMMS-generated integrated mathematics materials are used;
- graphics calculators, computers, and other appropriate technology are used as an integral part of the lesson;
- cooperative learning groups are a significant organizational structure;
- a variety of assessment methods are used, including open-ended questions; and
- the teacher assumes the role of facilitator of learning. (SIMMS, 1993,1992a)

Non-SIMMS classroom: A high school mathematics classroom which lacks at least one of the characteristics of a SIMMS mathematics classroom.

REVIEW OF RELEVANT RESEARCH AND THEORY

The following pages contain a review of literature pertinent to the thesis problem involving teacher-student interactions. The topics considered are the constructivist theory of knowledge and learning and its effect on teaching, types of teacher-student classroom interactions, and the process by which teachers adapt their philosophies of teaching and learning, and thereby their classroom behavior.

Constructivism

The Systemic Initiative for Montana Mathematics and Science (SIMMS) Project recognized the importance of having a theoretical basis for any curricular change. Reform projects in mathematics education prior to 1985 have been characterized, in research summary publications, as failing to adequately identify the goals desired and lacking a theoretical foundation (Kilpatrick, 1992; Wittrock, 1986). Robert Davis, a mathematics educator from Rutgers University, reviewed research on several "failed new math" reform projects of the 1960s and 1970s. He concluded that one reason they were considered to be failures was because they "lacked an adequate theory of how students learn mathematics"

(Davis, 1990, p. 94). Fortunately, this situation is changing as current mathematics education researchers attempt to link the complexity of classroom practices to theories of learning (Kilpatrick, 1992).

To this end, the SIMMS Project has developed a theoretical foundation for its program, and the constructivist theory of knowledge is a major part of that basis. Constructivist theory holds that knowledge does not exist separately from the knower and that each person creates his or her own knowledge of the world, or a school subject, through personal experiences (Ernest, 1989; Noddings, 1990; von Glasersfeld, 1990). Even in seemingly passive lecture situations, people are actively "constructing" their own understanding of what the lecturer is saying, fitting it into the framework of their previous experience.

Because constructivism appears to describe the way an understanding of mathematics is gained, it is currently receiving a great deal of attention in mathematics education literature. A survey of the Educational Resources Information Center (ERIC) database entries from the past ten years, revealed 80% of the entries relating to mathematics and constructivism were written during the past five years. To illustrate that constructivism is not just the latest "buzzword" in mathematics education, the following brief review chronicles the heritage of constructivism which goes back centuries.

In The Republic, Plato proposed the existence of a perfect realm of ideas, separate from the physical world (Plato, 1986/ 350 BC). This separation of the realm of ideas and the physical world suggests the infancy of constructivism. During the early 1600s, Rene Descartes questioned the validity of the notion that our world is an absolute entity, common to all people (Beardsley, 1960). About a hundred years later Immanuel Kant elaborated on that idea by proposing that reality is constructed by the mind that "knows it" (Marias, 1967). This ideas is the cornerstone of constructivism. In that same era, Jean Jacques Rousseau applied this idea to education. In Emile, he wrote that students should be allowed to learn some things for themselves in their own way. "Whatever he knows, he should know not because you have told him, but because he has grasped it himself" (Boyd, 1956, p. 73).

More recently, during the 1960's, Jean Piaget put forth the "constructivist" idea that knowledge is actively built by each person, not passively received. He saw the acts of assimilation and accommodation as ways people refined and updated their knowledge as they gained more experiences, i.e., as they learned (von Glasersfeld, 1990). The process of constructing knowledge involves encountering situations that challenge one's previously held concepts, reflecting on their relevance, and then, if appropriate, adapting one's concepts in line with the new experiences (Piaget, 1970).

Piaget, along with other proponents of constructivism, felt that the experiences through which we construct our knowledge are not limited to the physical world. We are social beings, and social interactions play a large role in helping us make sense of our world (Furth, 1969; Piaget, 1970). Students construct their understanding of a school subject as they interact with the teacher and other students. As they share their ideas with others, they are comparing their concepts with those held by others and adapting those that no longer fit their enlarged experience. This extension of constructivist theory, called social constructivism, is advocated by many mathematics educators (Baroody & Ginsburg, 1990; Bauersfeld, 1988; Ernest, 1989). Mathematical knowledge is seen as having resulted from interactions within a mathematics community, the members of the community having negotiated acceptable mathematical meanings from common problem situations (Cobb, Wood & Yackel, 1990; Ernest, 1989).

Jere Confrey, a mathematics educator at Cornell University, commented on how constructivist ideas impact pedagogy. "When one applies constructivism to the issue of teaching, one must reject the assumption that one can simply pass on information to a set of learners and expect that understanding will result" (Confrey, 1990, p. 109). Richard Skemp, a noted mathematics educator from England, holds that "concepts of a higher order than those which people already have cannot be communicated to them by definition, but only by arranging for them to encounter a

suitable collection of examples" (Skemp, 1987, p. 83). In the classroom the teacher's structuring of, and guidance through, mathematics problem situations helps the students construct their knowledge in line with that of other students and accepted practice (Confrey, 1990; Noddings, 1990).

If teachers accept constructivist theory it must impact the way they interact with their students. "If indeed a student does not understand, constructivism tells us that merely showing the student 'the right way' to do the problem will probably not suffice to straighten things out. We must probe deeper, and make contact with the student's ways of thinking" (Davis, Mayer, & Noddings, 1990, p. 188). This requires students to communicate their ideas and the teacher to be open to different frames of reference.

Studies have shown that constructivist methodology does "work" in the classroom. Paul Cobb and others (1991) studied the effects, on elementary school students, of mathematical activities and their accompanying instruction which were guided by constructivist ideas. "Students [engaged] in small group collaborative mathematical activity and then in teacher-orchestrated class discussions of their problems, interpretations, and solutions" (p. 6). Cobb concluded that the performance of the experimental group was superior to that of the control group in both problem-solving and traditional computational tasks.

Other researchers who studied instructional formats designed to overcome students' mathematical misconceptions

concluded that the most effective format was one in which the students took an active role in their learning (Baird & White, 1984; Novak & Gowin, 1984; Nussbaum, 1982). And, as noted by Jere Confrey (1990), "The philosophical approach that argues most vigorously for an active view of the learner is constructivism" (p. 107). Constructivist theory can offer explanations of how students learn, but it remains for teachers to translate that theory into classroom actions.

Teacher-Student Interactions

Research studies have shown that classroom interactions are one of the main factors affecting student success (Chismar, 1985; Mehan, 1982; Renninger, 1985; Troisi, 1983). These interactions are one way teachers can put constructivist theory into practice. The teacher-student interactions envisioned by SIMMS and the National Council of Teachers of Mathematics (NCTM)) cast the teacher in a constructivist-type role of a facilitator of learning rather than a purveyor of knowledge. This type of teaching has also been labeled "student-centered" and is an important part of a constructivist methodology. It involves teacher-student interactions which attempt to help students construct their own meanings from mathematical situations as advocated by constructivist theory. This is in contrast to "teacher-centered" teaching which keeps the students' attention focused on the teacher's view of the subject being studied.

The student-centered teaching approach contends that the student has the central role in the learning process.

> In student-centered teaching, students' existing conceptions are the starting point of an interactive teaching/learning process and students are helped by teacher's activities to construct their own knowledge . . . in line with that shared by the experts in the field. (Samuelowicz, 1992, p. 104)

Note the difference between the above definition and that of the more traditional "teacher-centered" teaching.

> In teacher-centered teaching students' existing conceptions are not taken into account, a teacher possesses the knowledge and transmits or imparts it to students. (Samuelowicz, 1992, p. 104)

The use of student-centered instruction is encouraged by many educators as a way to help raise students' self esteem and promote more academic success (Higgins, 1987; Knight, 1987; Stover, 1990). Student-centered teaching has increased student participation in the classroom as well as improved academic performance (Kelly, 1985; Troisi, 1983). Sharing control of instructional situations with the students is one form of student-centered teaching. For example, the teacher could involve students more "by not answering a direct question, perhaps deflecting it by asking other pupils what they think, or by inviting the questioner to explain what he has found out so far" (Pimm, 1987, p. 51). Instead of cutting off interaction with a direct answer, students are encouraged to actively participate. Students can discuss possible solutions, determine the correctness of the solution

based on mathematics, not "teacher authority," and gain confidence in their mathematical abilities.

The cooperative learning instructional format is another format for student-centered teaching. Neil Davidson (1990), noted author and researcher in the area of cooperative learning, reviewed over 80 research studies on cooperative learning and reported that in the majority of these studies the students in cooperative learning (student-centered) classes had better academic performance than the students in the control groups. "Students are not bored in class; many of them like mathematics more than when involved in teacher-centered approaches" (p. 60). Cora Agatucci (1989) found in her research at the college level that the cooperative learning structure was particularly helpful for traditionally "under-represented" groups of students, such as Hispanics.

The NCTM Standards, in describing student behaviors with action words like investigate, formulate, and verify, advocate a shift of emphasis in the student's role from passive recipient to active participant. They note that an accompanying shift is required in the teacher's role from a dispenser of information to a "facilitator of learning" using student-centered teaching strategies ([NCTM], 1989, p. 128). Today, teachers and teacher educators are trying to determine exactly what being a facilitator of learning, or student-centered teacher, means for the mathematics classroom.

The definition of facilitator of learning compiled by the researcher for this study (see page 8) was drawn from the NCTM Curriculum Standards, NCTM Professional Standards, SIMMS philosophy statements, and other current mathematics education literature. The definition describes teacher actions and teacher-student interactions which attempt to translate student-centered, constructivist theory into classroom practice. The items listed are very diverse and many will not be addressed in this study. All were included to provide a more complete overview of the SIMMS project's ideal facilitator of learning. It was assumed that the curricular materials would provide appropriate mathematical problem situations. The listed interactions were seen as facilitating students' work as they experimented, conjectured, communicated ideas, and constructed valid mathematical concepts from the given situations.

Teacher Change

How can teacher educators assist teachers in adopting constructivist-based methodology and promote different types of teacher-student interactions? "Constructivism does not offer pedagogical recipes or convenience. It asks much of us. Many familiar tools, and many familiar attitudes, must be questioned, modified, or just plain discarded" (Davis, Maher, & Noddings, 1990, p. 188). Michael Fullan, educational researcher and consultant to many educational reform projects, noted the importance of

applying constructivist ideas to teacher enhancement. He suggests that teachers need to be given the opportunity to construct their own understanding of a curricular change or innovation much as their students will construct their own mathematical meanings of mathematical situations (Fullan, 1991).

The NCTM Professional Standards for Teaching Mathematics (1991) is not alone in supporting the idea that a structured, supportive professional-development environment must be provided in order for teachers to reshape their classroom practice (Hord & Loucks, 1980; Rutherford, 1986; Sparks, 1984). Teachers contemplating a change in classroom behavior need time to experiment, to interact with other teachers implementing similar changes, and to try out the new roles suggested by the innovation (Fullan, 1991). These teachers need support from their curricular reform leaders, colleagues, and administrators as they venture into uncharted territory. "Change is a process and . . . the facilitating of change entails continuous and systemic interactions" (Heck, Steigelbauer, Hall & Loucks, 1981, p. 8).

The Educational Leaders in the Mathematics (ELM) Project conducted by the SummerMath for Teachers Program at Mount Holyoke College researched the effects of their inservice program on a teacher's thinking and classroom practice. The inservice training was based on "recent research and theoretical work" (Simon & Schifter, 1991, p. 309). Participating teachers had completed a two week intensive summer workshop, had weekly

classroom visits from ELM staff during the following school year, and attended an "advanced" workshop the next summer. Almost all of the teachers participating in the project adopted new classroom strategies for teaching mathematics. "More importantly, a significant number of the teachers came to base their instructional decisions on a view of learning as construction" (Simon, & Schifter, 1991, p. 328).

The Mathematics Curriculum and Teaching Program (MCTP) in Australia has also been successful in helping teachers change their classroom practice. They emphasize the importance of allowing the teachers opportunities to experiment.

> The evidence is overwhelming that teachers must have the benefit of time to reflect on the MCTP approach and to use it in their schools, and to interact with school colleagues if real change is to take place in mathematics teaching. (Owen & Johnson, 1987, p. 8)

The MCTP found that "one-shot" workshops seldom affected change in a teacher's classroom behavior. They noted that the most effective of the tested formats was a workshop which met at regular intervals during the school year enabling the teachers to try the suggested methodology in their classroom, then discuss the results at the next session.

Deborah Ball (1989) designed a teaching methods course which helped preservice teachers to view mathematics teaching and learning differently than they may have when they were students. The course presented mathematical content via

constructivist pedagogy and then encouraged the teachers to reflect on their own thought and learning processes. Several of the prospective teachers stated that the course shifted their philosophy of teaching to the constructivist view. However, they found it easy to fall back to previously learned patterns, such as mainly teaching algorithms, when put in a classroom situation. Other researchers working with preservice and inservice teachers have had similar results (Davis, 1990; Schram, Wilcox, Lanier, & Lappon, 1988).

When the University of Massachusetts offered a general mathematics course based on student-centered group learning, they needed to prepare graduate teaching assistants to teach in that environment. A major part of the training involved learning how to use clinical interview techniques employed by psychologists. The teaching assistants tried to understand the students' thought processes rather than imposing their own perspective of a problem on the students. They commented on having to adjust their ideas about the best way to teach and learn mathematics (Konold, 1986).

These research projects have shown that teachers' classroom behavior as well as their teaching philosophy can be impacted. The Research and Development Center for Teacher Education in Austin, Texas developed a structure for charting this impact. Seven different stages of concern about an education innovation were identified.

0: Awareness: Little concern about or involvement with the innovation is indicated.
1: Informational: A general awareness and interest in learning more detail about it is indicated. The person seems to be unworried about himself/herself in relation to the innovation.
2: Personal: Individual is uncertain about the demands of the innovation, his/her inadequacy to meet those demands, and his/her role with the innovation.
3: Management: Attention is focused on the processes and tasks of using the innovation and the best use of information and resources. Issues related to efficiency, organizing, managing, scheduling, and time demands are utmost.
4: Consequences: Attention focuses on impact of the innovation on students in his/her [teacher's] immediate sphere of influence. The focus is on relevance of the innovation for students, evaluation of student outcomes, including performance and competencies, and changes needed to increase student outcomes.
5: Collaboration: The focus is on coordination and cooperation with others regarding use of the innovation.
6: Refocusing: The focus is on exploration of more universal benefits from the innovation, including the possibility of major changes or replacement with a more powerful alternative. Individual has definite ideas about alternative to the proposed or existing form of the innovation. (Newlove & Hall, 1976, p. 12)

These stages were identified as the result of research conducted by Hall and Rutherford (1976) on the stages of concern experienced by teachers who were attempting to implement team teaching. The study established the usefulness of the stages-of-concern model and reported that teachers' concerns progressed

through different stages as they gained more experience with an innovation. Using the seven stages to compare a teacher's responses to open-ended questions about an educational innovation suggests the degree to which that teacher has "adopted" the innovation. Educational reform leaders would like all of the participating teachers to express stage 6 concerns. However, higher level concerns cannot be imposed by educational reform leaders or teacher educators. "Having concerns and changes of concerns is a dynamic of the individual. The timely provision of affective experiences and cognitive resources can provide the grist of concerns arousal and resolution, thereby facilitating the development of higher level concerns" (Newlove & Hall, 1976, p. 9). Similar to the constructivist methodology suggested for the classroom, teachers need to be provided opportunities to construct their own understanding of innovations, like student-centered learning, and their ramifications for the classroom.

Summary

The constructivist theory of knowledge has been a central theme in this review of literature. It holds that all knowledge must be personally constructed. It is a theory which is currently embraced by many mathematics educators as a good explanation of how students learn mathematics. If a teacher accepts the theory as a basis for teaching, his or her classroom interactions must become more student-centered. They must be structured to assist

the students in constructing their own mathematical knowledge. This represents a change in behavior for many high school mathematics teachers. Helping teachers make this change involves helping them construct their own understanding of the pedagogy much as they will help their students construct understandings of mathematics.

METHODOLOGY

Theoretical and Conceptual Framework

Teacher-student interactions have been studied for many years; however many of these studies were only interested in recording with whom the teacher was interacting and how often. For example, Ned Flanders devised a coding scheme for classifying classroom observations (Amidon & Flanders, 1967). The coding scheme consisted of recording, at preset intervals (usually every three seconds), the type of interaction taking place. Interactions were classified in six or seven categories such as teacher lectures, teacher criticizes student(s), teacher praises student(s), teacher asks questions, student responds, student asks question, and silence or confusion. Analysis was then done on type, frequencies and order of interchanges occurring, thereby providing a picture of the dynamics of the classroom. Because of the use of broad categories, this system gave little insight into the quality of teacher-student interactions, and a recent study suggested that the quality of interactions is more important than even the amount of time given to instruction (Reimers, 1991).

Presently, some researchers are looking at teacher-student interactions in a more qualitative manner using audio- and/or videotapes of the classroom, teacher diaries, and interviews with

teachers and students. Findings are interpreted with an emphasis on a holistic perspective. Descriptions of classroom settings along with a more detailed categorization of teacher-student interactions provide a more complete picture (Kouba, 1991; Mehan, 1982; Reimers, 1991; Renninger, 1985; Sikka, Tedder & Ewing, 1991). Consequently, qualitative research strategies were selected to structure this study of teacher-student interactions.

The following five characteristics of qualitative research, listed in Qualitative Research For Education by Bogdan and Biklen (1992), further indicate the appropriateness of qualitative research for a study of classroom interactions.

1. The natural setting is a direct source of data and the researcher is the key instrument. Much of the data for this study was collected in the classroom and supplemented by an understanding that was gained from the researcher observing the events rather than just looking at an outcome.

2. Qualitative research is descriptive. To accurately represent the complexity of classroom interactions they must be described rather than just quantified. This research report used descriptions and quotations from transcripts of interviews, field notes, and transcripts of audiotapes to describe patterns of teacher-student interactions.

3. Processes or actions are often the subject of qualitative research rather than just final outcomes. This study looked at the

processes of teachers and students interacting in instructional situations in mathematics classes.

4. Qualitative data are usually analyzed inductively. Patterns of interactions were drawn from the field observations and transcripts of interactions, rather than starting from an hypothesized pattern and trying to prove or disprove it.

5. "The ways different people make sense out of their lives" (p. 32) is a concern of the qualitative approach. Qualitative research can be helpful in studying teachers as they try to make their own "sense" out of an educational reform program such as the Systemic Initiative for Montana Mathematics and Science (SIMMS) Project.

Qualitative data collection is often done during contiguous site visits; however, limitations due to geographic distance between locations and other demands on the researcher's time made this impossible. "The goal of sampling is to get a representative view of individuals behavior and habitat" (Jacob, 1987). Intermittent site visits can satisfy this requirement. Firestone & Dawson (1981) even spoke of some benefits of intermittent visits.

> They make it possible to build rapport with respondents. . . . There is more opportunity to learn about facets of school life that are normally kept from strangers. Second, there are numerous opportunities to observe a variety of settings over an extended period of time (p. 21).

Consequently, the intermittent site visit approach, in spite of its interrupted observations, can be an acceptable observation strategy in documenting teacher-student interactions.

After data has been collected, it must also be presented in some effective format. Qualitative data can sometimes be effectively presented in a quantitative style. Evelyn Jacob (1987), a researcher from George Mason University, illustrated one such strategy which is often used by ecological psychologists. It produces detailed, objective descriptions of naturally occurring behavior that are amenable to quantitative analysis. There are three stages in conducting such a study: recording the stream of behavior, dividing the stream into behavior units, and analyzing the units. (Jacob, 1987)

> The most frequently used method for analyzing specimen records is based on the identification in the records of goal-directed actions of either the subject being observed or of other persons who are acting toward the subject. . . . The final step is describing the units' properties quantitatively. (Jacob, 1987, p. 7)

Erickson & Mohatt (1982) used this strategy when studying the classrooms of one Native American and one Caucasian teacher. They videotaped the classes for a total of 12 hours and from these tapes analyzed a variety of teacher and student behaviors. The data was presented with statements about the relative frequency of various behaviors. "One advantage of . . . a quantitative presentational style is that it provides the reader with a somewhat clearer picture of the magnitude of differences noted

that completely qualitative data wouldn't give" (Schofield & Anderson, 1984, p. 25).

This study used the quantitative presentational style described above as one way to report on the teacher-student interactions captured on the audiotapes. The qualitative data from class observations and teacher interviews put the resultant figures in a context, showing a more complete picture of the classroom interactions than either form would give alone.

Selection of Teachers for Study

The teachers for this study were selected from among the nine people who were observed and interviewed prior to the 1992 SIMMS Summer Teacher/Leader Institute. Those considered also had to be pre-piloting the full Level One SIMMS program during the 1992-1993 school year. Since all the institute teachers had undergone an extensive screening, the only other factors used for selection were school size, geographic location, participation in a pre-summer interview, and gender. Five teachers were selected, but one was later dropped due to family problems. Each of the four teachers selected had at least eight years of teaching experience and had taught most of the traditional high school curriculum. Two teachers were women, and two were men.

Diversity of geographic location was considered, within the limitation of the researcher's ability to visit each location several

times. One of the research sites was a large high school, enrollment of about 1,700, located in a city with an area population of 55,000. The teacher selected at that school, who will be identified as Adam, was one of 12 people teaching in the mathematics department. The second site was a single-industry town with an area population of approximately 3,500. The high school had an enrollment of 500, with approximately 20% American Indian students. The teacher, who will be called Carol, was one of four mathematics teachers in the school. The other two research sites were ranch/farm communities. One, a community of about 1,400, had one school, the high school portion of which enrolled about 100 students. The teacher, who will be called David, was one of two mathematics teachers. These teachers taught grades 7-12. The other site had a school with an enrollment of about 200 students which drew from an area of approximately 3,000 people. The teacher, Betty, was one of two mathematics teachers in the school. A classroom profile of each teacher appears at the beginning of the next chapter.

SIMMS Teacher Preparation

The 1992 SIMMS Teacher/Leader Institute was held to prepare teachers to participate in field testing the SIMMS program. The institute met seven hours a day, five days a week for six weeks. The 32 teachers who attended were chosen from a pool of

over 100 applicants. They were selected on the basis of the quality of recommendations, teaching experience, leadership potential, geographic distribution, and gender.

The institute presented the teachers with an opportunity to experiment with different types of technology and instructional structures. The goals of the institute were to

- prepare teacher/leaders to teach the SIMMS integrated mathematics materials using advanced technology where appropriate;
- provide an environment in which teachers can examine and question their beliefs about mathematics, teaching and learning;
- develop a statewide network of teacher/leaders to provide inservice in the use of SIMMS materials;
- provide teacher/leaders with an intensive summer experience teaching SIMMS materials to American Indian youth with attention to gender equity issues; and
- prepare teacher/leaders to promote the use of a statewide telecommunications network using a variety of modalities. ([SIMMS], 1992b, p. 1)

To reach these goals the institute leaders provided opportunities for the teachers to work through sample SIMMS modules, much as their students would during the school year. There were opportunities to teach selected parts of the modules to American Indian students who were attending a four-week mathematics workshop at the same location. These and other teaching situations were discussed after being observed in person

and/or on videotape. Ways of interacting with the students as they worked in groups or as a whole class were discussed.

During the sessions on technology, cooperative learning and SIMMS philosophy, the leaders of the institute and visiting consultants tried to modeled the facilitator of learning role the teachers would be expected to assume. Other professional growth opportunities were provided in terms of participating in cooperative learning groups, practicing writing, and confronting gender and ethnicity equity issues. All participants were encouraged to use personal journals to reflect on proposed changes. With permission of the participants, the researcher read the journals and shared summaries of the entries with other SIMMS personnel. The information was used to tailor the institute to the needs and interests of the participants.

The teachers also designed informational presentations on the SIMMS project for their colleagues, administrators and community. These presentations were given during the pre-piloting year to their schools and communities to acquaint people with the long- and short-term goals of the SIMMS project for high school mathematics students.

Statement of Researcher Bias

It was the researcher's position that patterns of teacher-student interactions would not differ significantly between a

teacher's SIMMS and non-SIMMS classes. No specific interactions were anticipated, just consistency in a teachers' general pattern of interactions. The way teachers interact with their students was thought to be a product of their beliefs about mathematics teaching and learning, and habits of teaching, not a product of the curriculum.

Experienced teachers have often established a pattern of classroom behavior which gives the "desired results." Now the NCTM is trying to change the nature of those "desired results" and this requires a change in teacher behavior. Many teachers outwardly embrace these new ideas, but often do not translate them into changed classroom behavior. While the SIMMS program may make it easier for the teacher to assume new roles, such as facilitator-of-learning, it does not necessarily produce a change.

Association with the SIMMS project and the review of current literature in mathematics education influenced the researcher's views on appropriate teacher-student interactions. Since completing this study and returning to college teaching, the researcher has attempted to implement the interactions described in the facilitator of learning description. Finding an appropriate balance between student-centered and teacher-centered interactions is an on going challenge.

Data Collection

Data for the study were collected by the researcher during the fall semester of the 1992-1993 high school year. During September, classroom observations, videotaping and audiotaping techniques were tested and refined. The Flanders Interaction Coding Scheme was tested and abandoned because it was difficult to hear small group teacher-student interactions without standing right next to the teacher, and it was felt that the students did not interact normally under those conditions. Audiotape recording of the classroom dialogue was selected for documentation of teacher-student interactions. This permitted the use of more detailed interaction categories.

Data collection visitations started in October. Each teacher was visited three times with five weeks between visits, the final visit occurring in January. Classroom observations and audiotapes of teacher-student interactions were made on two consecutive days in one SIMMS class and one non-SIMMS class. Selection of which SIMMS and which non-SIMMS classes to include in the study was made on the basis of teachers' schedules; similarity of level, when possible, of non-SIMMS class; and effective use of researcher's time. The selected non-SIMMS classrooms were not ninth-grade classes because the teachers in the study taught the SIMMS program to all of their ninth-grade students. Non-SIMMS

classes observed included eighth grade mathematics, geometry and algebra/trigonometry.

All observed classes were audiotaped. Most often, the teachers wore a small tape recorder attached to a belt, or placed in a shirt pocket during the observed class period. One teacher did not like to wear the recorder and, on occasion, asked that the recorder be placed on a table at the front of the room. This was done except when the class was engaged in group work and there was a need to record individual teacher-student interactions.

The researcher had been introduced to the students during the September preliminary visits. The students were informed that the purpose of the upcoming repeated visits was to observe the way the class is run and that neither teacher nor students were being "graded." During subsequent visits, the researcher was generally ignored by the teacher and students. During whole class instructional situations, the researcher observed from the back or side of the classroom and took notes on classroom activities. The researcher walked around the room during group work, noting student activities. An effort was made not to be near the group which the teacher was assisting, thereby obtaining an audiorecording of a more "usual" interaction between teacher and student(s).

In order to provide some additional views of the classrooms under study, teachers videotaped the classes during the week in which the observations were done. Most of the students appeared

to forget about the video camera, but a few did not like it and asked that it to be focused on a different group. Generally, it did not disrupt the usual flow of the classes.

Teachers were interviewed during each of the three site visits, each interview lasting from 30 minutes to an hour. An interview guide (see Appendix A) was used. The researcher who works with an interview guide must allow for the possibility that what interested the other teachers interviewed may be of little interest to the teacher currently being interviewed (Seidman, 1991). Consequently, while all teachers were asked basically the same questions, follow-up questions varied, as the teachers talked about their experience pre-piloting the SIMMS materials.

All teachers who participated in the 1992 Summer Institute met for two-day conferences during the 1992-1993 academic year, in October, January, and April. The purpose of the meetings was to provide another avenue of support, allow the teachers to exchange ideas, provide inservice opportunities for new ideas, and obtain feedback for SIMMS administrators on the progress of the pre-pilot. These meetings were used as informal data gathering opportunities during both formal meetings and social gatherings.

Multiple Data Sources

Multiple forms of data were used to document the teacher-student interactions. Each form had a specific purpose, but all

worked together to support findings. The field notes taken during classroom observations were used to describe the general characteristics of the classroom, such as physical setup, different types of learning situations, and their duration. Transcripts of audiotapes were used to examine teacher-student verbal exchanges. Videotapes of observed classrooms supplemented field notes and helped determine general characteristics of a given classroom and provide a "before" and "after" view of observed lessons. Transcripts of teacher interviews provided information on the teacher's interpretation of classroom interactions.

Description of Transcript Coding

Detailed transcripts were made of the audiotaped class sessions. Only *instructional time* was used for analysis. All teacher-student dialogue concerning disciplining of students or administrative tasks, such as taking roll and reading announcements, was deleted. All time during which students were taking pencil and paper tests was also not included. The transcripts were then partitioned into separate teacher-student interactions. An interaction was defined as a dialogue between teacher and class or teacher and student(s). A new interaction was delineated when the nature of the exchange no longer fit the category being used.

The facilitator-of-learning description generated for this study (see page 8) was used as a preliminary coding schema. Additional codes were added to the list as interactions were encountered which did not fit the existing categories. After approximately one third of the transcripts had been reviewed, a final list of codes was established and all transcripts were re-coded. The final list of the codes follows below.

The teacher:

2. assists students in organizing cooperative learning groups;
3. has students do class presentations;
6. demonstrates use of appropriate technology to help solve problems;
7. encourages students to use appropriate technology to help solve problems;
8. requires students to express mathematical ideas in written and oral form;
10. encourages discussion among students about problems and possible solutions;
11. attempts to understand student's rationale for his/her work;
12. brings up evidence that conflicts with a student's interpretation so student can reexamine his/her thinking;
13. asks process-oriented questions;
14. asks open-ended questions;
15. moderates discussions on student generated ideas;

16. helps students to rely on themselves to determine whether something is mathematically correct;
18. asks judgment questions;
di. uses direct instruction;
ra. reads (or has student read) answers to assignment from answer book;
sa. asks short answer questions;
sr. has students report on group work;
ta. helps with the mechanics of the calculator or computer; and
td. gives general directions on how to proceed with the work.

A more complete description of the codes and the situations in which they were used may be found in Appendix B.

The following are a few of the more frequently used codes and situations in which they were used.

10: Encourages discussion among students about problems and possible solutions: Teacher does not immediately pass judgment on suitability of problem solution, but allows students to consider possible alternatives.

13: Asks process-oriented questions: Teacher's questions focus on the way a problem is solved more than on the solution. The code was also used when a teacher asked which algorithm was appropriate in a given situation.

14: Asks open-ended questions: Teacher's questions are open to interpretation and/or do not have an expected response.

15: *Moderates discussions on student generated ideas:* Teacher invites other students to comment on ideas which were generated by students.

di: *Uses direct instruction:* Teacher assumes authority by either providing information about the topic, demonstrating an algorithm, or telling students their answers were correct.

sa: *Asks short answer questions:* Questions from the teacher have an expected short answer and teacher passes judgment on correctness of that answer.

The number codes were derived from the interaction's position in the facilitator-of-learning description. The code numbers are not sequential because some of the facilitator characteristics could not be assigned to a single classroom interaction and were eliminated from the coding list. Letter codes were assigned to those interactions which were added to the coding list. Interactions initiated by a student question were marked with an "sq" preceding the interaction code.

If both number and letter codes fit an interaction, the number code was given precedence. If two numbers fit an interaction, the higher number was used. Preliminary use of the Flanders coding schema influenced the decision to use a single code for each instruction.

While this coding system makes use of categories similar to those used by Flanders, it is different in application. Flanders' interaction coding system used general categories and required the

researcher to make a judgment on the spot as to the nature of the interaction. The system used for this study allowed more specific categories of interactions and permitted the researcher time to consider the most appropriate category for a specific interaction.

A computer database was created from the coded data. Each database record included a transcript identification number, the text of the interaction, the assigned code, the length of the interaction in characters, a classification as to whole class or small group situation, and a sequence number. Small group interactions were defined as those occurring between the teacher and from one to four students.

The reports generated from the transcripts were as follows:

a) full classroom transcript of all instructional interactions;
b) coded database version of classroom transcript;
c) summary of codes in a classroom transcript;
d) summary of codes from all transcripts from an individual class;
e) summary of codes from all SIMMS class transcripts;
f) summary of codes from all non-SIMMS class transcripts.

All summaries included calculation of the percentage of instructional time (see page 38) spent in each type of interaction and the percentage of instructional time spent in whole class instruction.

Validation

Each teacher in the study previewed their classroom profiles and summaries of coding of their classes' transcripts and the composite classes. All of the teachers found the profiles to be accurate after minor modifications. The transcript analysis prompted questions about exactly which interactions were being summarized and compared. Most expressed some surprise at the results but, after studying the coding categories and discussing their use, agreed the findings were representative of their teaching. The videotapes taken on non-visiting days confirmed that observed classes were generally typical class sessions.

The goal of the interview is to understand how the participants understand and make sense of their experience. If the interview structure allows participants to explore their feelings in a way that makes sense to them as well as to the interviewer, then it has gone a long way toward validity (Patton, 1990).

The interaction coding schema was reviewed by two different professors of education. They were each given a list of the codes and an explanation of the way they had been used. Both reviewers worked independently on the sample pages from two different transcripts. The same character count strategy which was used in quantifying the teacher's interaction formed the basis for the following comparison. Since the analysis of the transcripts was done on the basis of student-centered and

teacher-centered interactions, comparison of these categories rather than individual "codes" was used. Both of the reviewers and the researcher agreed on the coding of student-centered or teacher-centered interactions, on 50% of the transcript samples. The researcher agreed with one of the reviewers on about 60% of the sample transcripts and with the other one on about 80% of the sample transcripts. Discussion with the reviewers after they completed their coding showed the difficulty of categorizing classroom interactions from written transcripts only. In spite of being briefed on the classroom scenario, the reviewers interpreted some situations quite differently from each other and the researcher. If the reviewers had been able to see a videotape of the sessions transcripted they may have coded it differently. As noted in the first characteristic of qualitative research (see page 27), observation of an event gives added information not available in its purely written form.

FINDINGS

Teacher Profiles

The four teachers in this study will be identified as Adam, Betty, Carol, and David. They are all experienced teachers and have taught all levels of high school mathematics. The teachers came into the Systemic Initiative for Montana Mathematics and Science (SIMMS) project knowing very little about it, except that it was a multi-million dollar joint undertaking of the National Science Foundation (NSF), Montana Council of Teachers of Mathematics (MCTM) and the State of Montana. They knew SIMMS was attempting to improve mathematics education in Montana and they wanted to be part of that effort. All of the teachers are members of MCTM. Three of them had participated in another program funded by NSF and sponsored by the MCTM entitled Integrating Math Programs And Computer Technology (IMPACT).

The following profiles describe each of the four teachers in the study. Comparisons were made between each teacher's non-SIMMS and SIMMS classes as to the physical classroom setting, technology usage, and general teacher-student interactions. An understanding of a teacher's classroom situation is essential when trying to interpret interaction patterns.

Information for this overview is drawn primarily from classroom observations, personal interviews and informal conversations.

Adam

Adam has 11 years of teaching experience and is teaching in a large high school (enrollment about 1,700). Both of his observed classes had approximately 30 students. Adam pre-piloted SIMMS materials in two different classes, both were made up of 9th and 10th grade students who would have been in a pre-algebra class. Data for this study were taken from only one of those SIMMS classes. The non-SIMMS class was a junior level algebra/ trigonometry class.

The SIMMS and non-SIMMS classes met in different rooms. The non-SIMMS classroom had individual student desks arranged in rows, which the students rearranged when they worked in groups. The non-SIMMS students chose their own groups of from two to five people, and moved their desks accordingly.

The SIMMS classroom set-up had long tables (see Figure 1) arranged in two rows of four tables, with a computer situated on the end of the table closest to the side wall. For whole class situations, students sat in

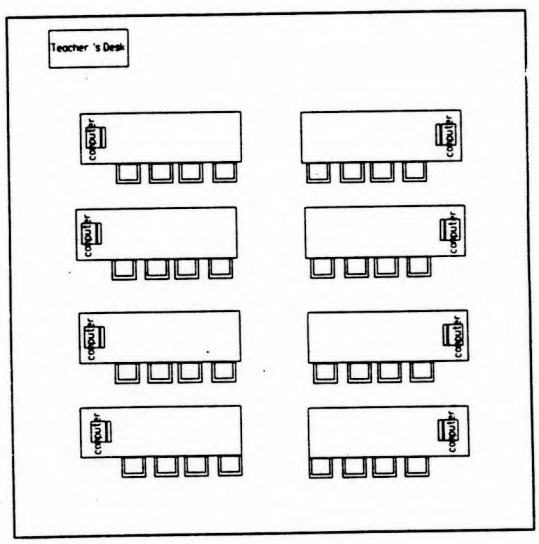


Figure 1. Adam's SIMMS Room

chairs arranged on one side of the table, facing the front of the room. During group work, some of the students moved their chairs to the other side of the table so the members of the group could face each other. Students were randomly assigned to groups of three or four.

Technology use in the non-SIMMS class consisted of graphics calculators which were distributed when Adam deemed their use appropriate. In the SIMMS class graphics calculators were always available and students made use of them and/or computers as needed for the class activities.

The instructional format of Adam's non-SIMMS class was usually direct instruction in a whole class situation, with frequent use of short answer questions. The class usually started with Adam answering questions on the previous assignment and then doing a presentation on that day's lesson. During this presentation, students were often asked to provide the next step in solving a problem, or the results of a calculation. This sequence of events usually occupied the entire class period. Non-SIMMS students were observed working in groups on two different visits. The first time, they worked on an assignment for the entire class period while Adam circulated among the groups answering questions. The other time was a make-work situation, for part of a period, to keep them busy while Adam corrected some assignments they needed that evening for study purposes.

The SIMMS class presented Adam with a very different format. There did not seem to be a discernible "typical day" like there was in the non-SIMMS class. The students were observed giving group presentations, working in groups on activities, engaging in class discussion, and listening to teacher-given directions and explanations. There was no predictable pattern of instructional format as there was in the non-SIMMS class. Adam remarked during the first interview, "I don't think you could have prepared me for what was about to happen . . . it's just so different." Classroom discipline and keeping students on task were a problem for Adam. "It's a lot of freedom for these kids. . . . They've never had this much freedom to sit at a table and be responsible to do something like that. . . . And it's really hard." However, toward the end of the researcher's observation schedule the class seemed to have settled down and was more attentive during class discussions and more on task during group activities.

During all three interviews Adam commented on not knowing his SIMMS students as well as his non-SIMMS students. This he attributed to the different structure of the SIMMS class. He noted: "I can teach you a lot better if I know who you are. . . . But I don't expect you to let me into your life if I don't let you into mine." He described his usual classroom pattern of taking time to tell the class about himself and his family at the start of some class periods. He believed that students then felt more comfortable in coming in before and after school when he could get to know them.

The SIMMS cooperative learning groups were seen as a barrier to this type of interaction. The students were working in groups and Adam was hesitant to interrupt for socialization.

Another influence on Adam's relationship with his SIMMS students was time. The first SIMMS modules took much longer than the anticipated two to three weeks and Adam, along with others pre-piloting the program, felt pressed for time. He felt the entire class period was needed to complete the activities and related discussion. "There just isn't time to sit and visit with the kids . . . . You can't afford to lose that time."

The observed teacher-student interactions were similar in both Adam's SIMMS and non-SIMMS class, in spite of his frustrations with the SIMMS format. The structure was teacher-centered, whole class instruction most often, but there were opportunities for students to participate and they seemed willing and eager to do so.

Betty

Betty has 12 years teaching experience and is teaching at a small high school (enrollment about 200). Her observed non-SIMMS class was a sophomore geometry class with 24 students. The SIMMS class was made up of 14 freshmen who would normally have been in a pre-algebra class.

All of Betty's classes were held in the same room (see Figure 2). The set-up had students' desks in rows in the center of

the room with computers on small tables at the back and side walls. The students put their desks together whenever they worked in groups. Betty assigned students to groups consisting of three or four students in both her SIMMS and non-SIMMS classes.

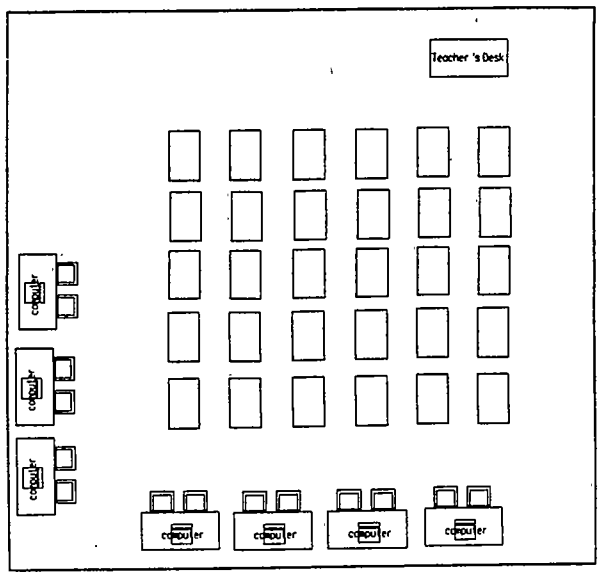


Figure 2. Betty's Room.

Although both SIMMS and non-SIMMS classes used the computers, the SIMMS class used them more frequently. Most of the computer work was done with the students working in pairs. Graphics calculators were used only in the SIMMS class, and they were available whenever students needed them.

The non-SIMMS class often started with Betty having students present answers to the homework. This was sometimes done by groups, each group having the responsibility for presenting a different set of problems. Betty would randomly select a student from the group to present a problem. New material was then presented by Betty, in a lecture format, after which the students worked in their groups on the new assignment. As the students worked, Betty would walk around the room monitoring progress and answering questions. If there were not many

questions, she would work at her desk and students would come up to her to ask questions.

The SIMMS class had a more varied routine. Betty usually started the class with a description of the activities for the day. The students worked in small groups, individually or at the computer stations as the work required.

> In the SIMMS class, there's a lot of days it's get in your groups and this is what you have to do. . . . Where with the geometry, they'll usually be a whole class thing at the beginning of class, and then they may go into groups. So when I say more structured, maybe I'm just saying just more of a routine where in the SIMMS class there's never a routine at all.

Betty would lead whole class discussions when students had completed an activity or section of the module.

Betty found the SIMMS class frustrating at first, but then it came to be her favorite class. "In September, . . . I really had a hard time. . . . The kids were hard to deal with at first. They didn't understand the group stuff. . . . Now, I'm not feeling that way. . . I enjoy it."

During group activities, Betty interacted more with the students in her non-SIMMS class than the SIMMS class. As she walked around the classroom monitoring what the students were doing she tended not to interact unless the students asked questions. The non-SIMMS students tended to ask her more questions and even seemed to come up with questions whenever she came near their group. The SIMMS students did not ask as many

questions; they seemed to be more independent or at the least less willing to ask questions. Betty felt the SIMMS students were more independent and more willing to try things on their own.

The SIMMS class consisted primarily of low-ability students. Several qualified as Chapter I students. Consequently, Betty felt that she had problems that others who were pre-piloting with average ability or college-prep level students may not have experienced.

> The kids I am teaching are not typical. They're not good students [academically]. They're on our weekly failing list a lot . . . I might be able to tell my geometry kids, who are better students, "I'm looking for this, this, and this" and I would get it. But with these kids I can say, "I'm looking for this, this, and this--" and I won't get it with them.

She felt she needed to be more directive in her teaching with her SIMMS students than other pre-piloting teachers. However, the data indicated that she was not the most directive of the study teachers.

Betty used very similar teacher-student interactions in her SIMMS and non-SIMMS classes. She felt her SIMMS class needed the structure of "lecture" situations, but she was also trying to apply methodologies discussed in the SIMMS workshops to her non-SIMMS classes.

> When I am doing group things in geometry I feel like I behave the same way as when I'm doing group things in SIMMS, and I feel like when I'm up front lecturing I'm doing the same things . . . so, actually, there isn't a whole lot of difference. . . . It's so much more fun to be doing this [SIMMS], than it is to have these lessons all prepared, and be up there the whole period. And in that sense I think there may be a difference.

Carol

Carol has been teaching at a medium size high school (enrollment approximately 500) for eight years. Her non-SIMMS class observed was a second year Algebra of twenty-eight students. She pre-piloted SIMMS in two different classes, one primarily freshmen and the other sophomores and juniors. The data for this study was taken from the freshman class. It had 28 average-ability level students.

Both SIMMS and non-SIMMS classes use the same classroom (see Figure 3). The classroom set-up had seven tables distributed as evenly as possible around the room. Each table had a computer and chairs for four or five students.

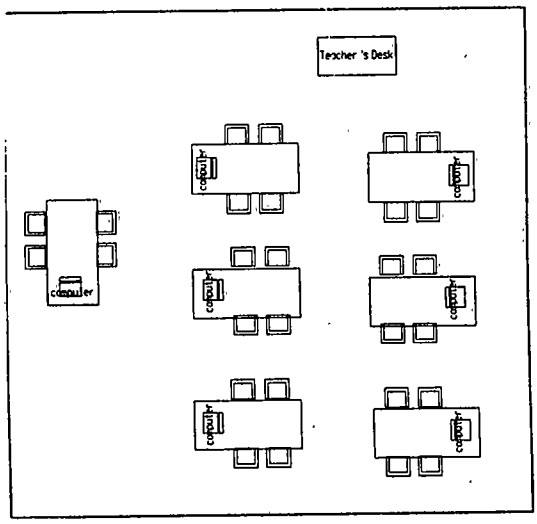


Figure 3. Carol's Room

SIMMS students were assigned to their groups through teacher choice or random selection. These groups were changed for each module (about every three weeks). Non-SIMMS students chose their own groups at the first of the semester and generally stayed with that group.

The non-SIMMS students did not use the computers except to play games after they finished their next day's assignment. The SIMMS students used the computer as needed for activities. Graphics calculators were available to all students whenever needed. The only observed usage of calculators in the non-SIMMS class did not require the use of the calculator's graphics capability.

The non-SIMMS class usually started with Carol reading the answers to the previous day's assignment and giving the students time to ask questions on what they missed. This question and answers session was conducted in either whole class, one-on-one, or small group format. After the assignment papers were collected, the new material was presented in lecture format and the next assignment given. Sometimes Carol would give a short explanation of a topic, have the students work at their tables for a while, and then call the class back to order to complete the explanation. Short answer questions were often a part of the presentation as Carol asked students to give the next step of a problem or the results of a calculation. Students seated at the tables helped each other with the assignment while Carol

circulated around the room answering questions and keeping students on task.

Outwardly, Carol's SIMMS class didn't look different from the non-SIMMS class except that the classroom was somewhat noisier as students worked on activities in their groups.

> I've always thought kids should work together. I've always felt that noise level had no bearing on the amount of learning that's taking place. Maybe I'm kind of lucky, because I think my classroom's probably changed as little as it could going to a new program.

As in the non-SIMMS class, Carol spent much of the time in the SIMMS class interacting with the students in small group and individual situations. However, she felt the interactions were less directive in the SIMMS class.

> In the SIMMS [class], I like them to come up with their own answers and discuss things and question what I'm saying. I notice myself in my Algebra II classes, I already know what the right answer is and I'm less open to questions. . . . I have too much of a tendency to jump in and say, "Wait a minute. Why don't you try this?" Where in SIMMS I let them wander a lot more. That's the one difference I can see.

Carol's observed personal relations with her students were quite similar with both SIMMS and non-SIMMS classes, but her instructional teacher-student interactions were noticeably different.

David

David teaches at a small school with a high school enrollment of approximately 100. He has ten years teaching experience. The observed non-SIMMS class, an eighth grade mathematics class, had 24 students and the SIMMS class had 20 average ability level students.

Both SIMMS and non-SIMMS classes used the same room (see Figure 4), but in different seating configurations. The room had individual student desks in rows in the middle of the room and five long tables at the back of the room coming out from the wall. Each long table had a computer and four chairs. Most of the students in the non-SIMMS class sat in the rows of desks. One or two pairs of students sat at the back tables. One small group of students, who had scored well on a pre-test of the current topic, worked together at a table using a different book. Non-SIMMS students did not work in groups. David noted "[In the eighth grade class] I'm using a kind of a buddy system more than the cooperative grouping." During the SIMMS class, all of the students sat at the tables in the back of the room with their teacher-assigned group.

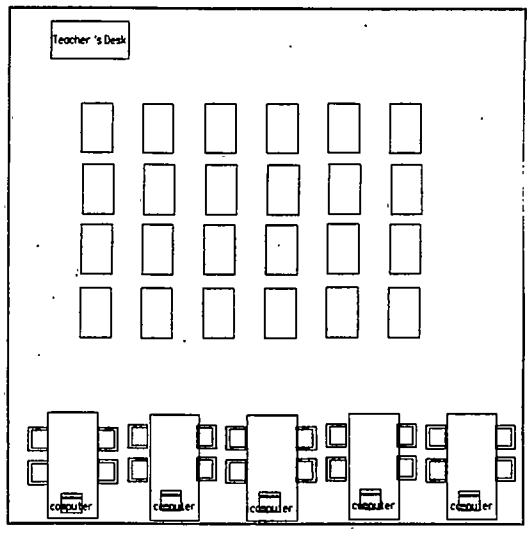


Figure 4. David's Room

The only technology used by the non-SIMMS students was standard four-function calculators. Each SIMMS student had a graphics calculator to use as needed and each group had a computer to use as needed for the activities.

The non-SIMMS class usually started with David either reading answers to the assignment or having a student do so. After answering student questions on the assignment, he presented the new material in a mostly lecture format. However, students were asked for input from time to time during the presentation. The students were then given the rest of the period to work on the new assignment. Most of the students worked independently; some compared answers with their neighbors. The room is usually very quiet. Students raised their hands when they needed help and often whispered their questions. In turn, David whispered or spoke in very low tones when he responded.

This is in sharp contrast to the SIMMS class. These students were almost always working in groups at the tables. The noise level in the room was higher than the non-SIMMS class as the students discussed their activities. Students usually called out to David when they needed help or wanted to share their "discoveries". He would acknowledge their request and then get to them in order. David spent most of the class period monitoring the groups' progress, answering questions and keeping students on task. He would lead whole class discussions after the student

groups had completed their activities and related module exercises.

David was the only study teacher who commented on feeling prepared to teach the SIMMS modules. This is probably due to his less structured approach to presenting the modules.

> I just kind of turned it over to the kids and said, "This is what I expect you to get done this period.". . . I think that sometimes if you read too far ahead, then you try to guide the kids too much.

David's classroom interactions were shaped by his view of the SIMMS philosophy. He felt the objective of the SIMMS project was

> to make the students less dependent upon a teacher and more dependent upon each other and to help them become more problem-solvers so that they learn how to solve their own problems as they arise rather than having the teacher show them a particular technique and then make them do the practice. It's to get them to think, to be a little more creative.

This view seemed to make him more aware, in his SIMMS class, of interacting in a way that would help his students construct their own meanings from the experiences presented by the SIMMS modules.

Analysis of Classroom Transcripts

Summary information on coded classroom transcripts was analyzed for patterns within and between SIMMS and non-SIMMS classes. A composite of all SIMMS classes and a composite of all

non-SIMMS classes were generated as benchmarks for comparisons of the individual teachers. Three main areas yielded patterns: (1) whole class vs. group instructional format, (2) student-centered interactions, and (3) teacher-centered interactions.

Whole class instruction refers to any instructional time during which all of the students were supposed to be focused, as one large group, on the same interaction. Examples of instructional situations that fell into this category were teacher-lecture, class discussion and student presentations. Instructional time not designated whole class situations was assigned small group designation even though some of the time the students were working individually. Both student-centered and teacher-centered interactions took place during whole class and small group situations.

For this study the term "student-centered interactions" will refer to teacher-student interactions which encourage students to construct their own meanings from mathematical situations. They are interactions which attempt to empower the students mathematically. These are the types of interactions encouraged by the NCTM Standards and the SIMMS philosophy.

The following codes from the interaction list (see page 38) were included as student-centered interactions:

8: requires students to express mathematical ideas in written and oral form;

10: encourages discussion among students about problems and possible solutions;

11: attempts to understand student's rationale for his/her work;

12: brings up evidence that conflicts with a student's interpretation so student can re-examine his/her thinking;

13: asks process-oriented questions;

14: asks open-ended questions;

15: moderates discussions on student generated ideas;

16: helps students to rely on themselves to determine whether something is mathematically correct;

18: asks judgment questions; and

sr: has students report on group work.

See Appendix B for a complete description of these codes.

The term "teacher-centered interactions" refers to teacher-student interactions which focus attention on the teacher and the teacher's frame of reference for the topic of instruction. The three interactions which were included in this category are:

di. *uses direct instruction*, i.e. lectures or shows students explicit steps to complete a problem, in whole class, small group or individual situations;

td. *uses teacher given directions*, i.e. gives specific directions on the logistics of completing an assignment; and

sa. *asks short answer questions*, i.e. uses "fill-in-the-blank type questions.

For more complete descriptions see Appendix B.

Composite Classes

A composite SIMMS class were generated by combining all the interactions from all of the SIMMS classes. A composite non-SIMMS was generated in the same manner. By comparing these composite classes, some general similarities and differences can be noted about percentages of instructional time (see page 38) devoted to various categories. The percentages given are based on the number of characters comprising an interaction as contained in the classroom transcripts. These percentages are approximations and no significance is assigned to small differences. The intent is to only show relative magnitudes of different interaction usage not exact percentages.

Whole class instructional situations (see page 59) were used about 60% of the time in both types of classes (see Figure 5) although they were used somewhat more in non-SIMMS classes (see Tables 3 and 4, pages 138-139). The remaining instructional time was spent in small group or individual work. While all the teachers differed in the amount of whole class instruction they used, all but one used similar amounts between their SIMMS and non-SIMMS classes. The SIMMS Project emphasized the use of group learning but did not mandate a particular percentage of instructional time for that format. Whole class or group instructional structures seemed to have little effect on use of student-centered or teacher-centered interactions. The same

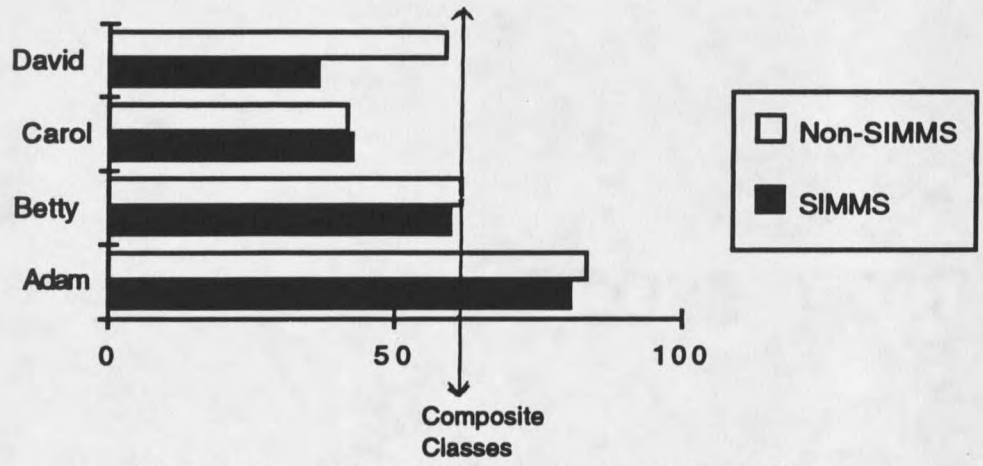


Figure 5. Whole Class Instructional Time (percentages per teacher).

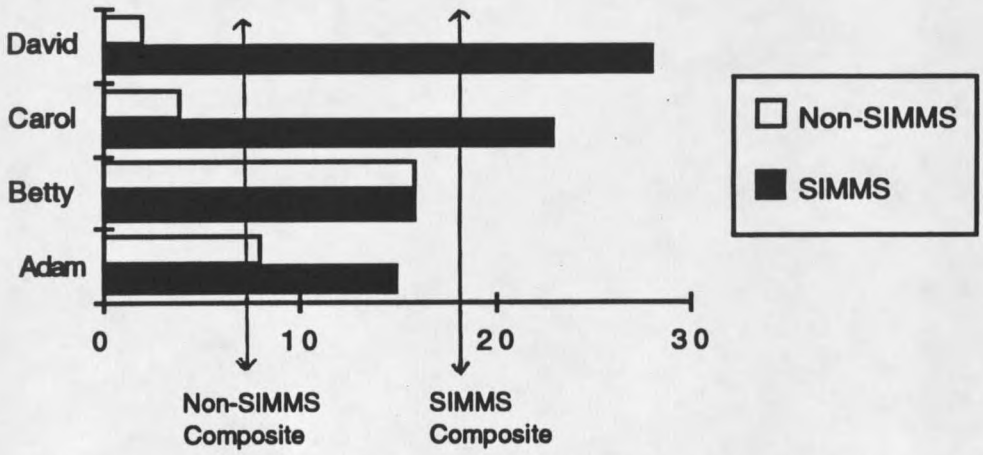


Figure 6. Student-Centered Interactions (percentages per teacher).

ratios of these interactions were observed in both whole class and small group settings.

Student-centered interactions were used more than twice as often in the composite SIMMS class as the non-SIMMS class, 18% as compared to 7% (see Figure 6). Three of the study teachers showed a marked difference in their use of student-centered interactions from the composite classes as well as between their SIMMS and non-SIMMS classes. The most used student-centered interaction in the composite SIMMS class was *encouraging discussion among students about problems (10).* It was used at least twice as often as the next two most frequently used student-centered interactions, about 8% of the time. In the composite non-SIMMS class, the interaction *asking process-oriented questions (13)* was the most frequently used (4%) with *encouraging discussion among students about problems (10)* next, but half the usage of *(13).* Both types of composite classes had eight of the ten different student-centered interactions.

Another major difference between the composite classes was the percentage of instructional time devoted to teacher-centered interactions, approximately 55% in the composite SIMMS class compared to 85% in the non-SIMMS class (see Figure 7). *Direct instruction (di)* accounted for 28% of the instructional time in the composite SIMMS class while constituting 50% of the composite non-SIMMS class. *Teacher given directions (td),* however, took almost twice as much time in the SIMMS classes,

23% as compared to 13% in the non-SIMMS class. *Short answer questions (sa)* were used less frequently in SIMMS classes as compared to non-SIMMS classes, 7% and 20%, respectively.

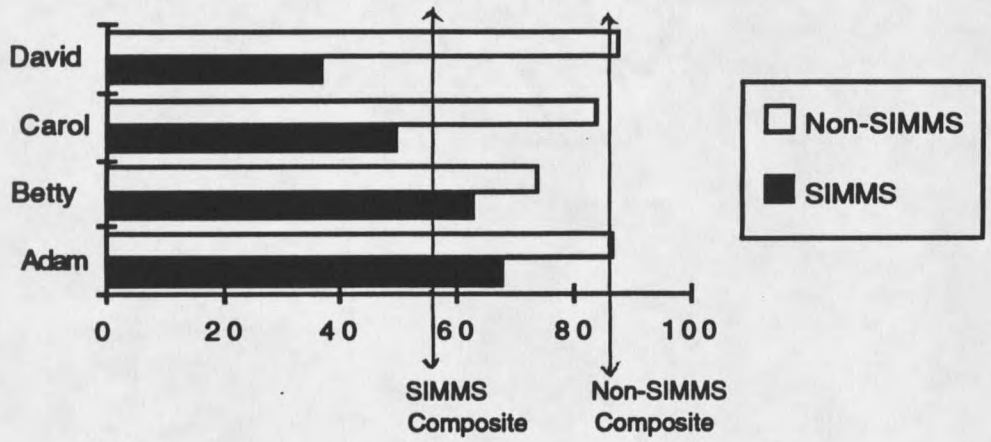


Figure 7. Teacher-Centered Interactions (percentages per teacher).

Adam

In Adam's classes, whole group instruction was used more often than in the composite classes. It comprised over 80% of the instructional time in both types of Adam's classes as compared to 60% for both types of composite classes (see Figure 8). However, the percentages of student-centered interactions were close to those of the composite classes. He used almost double the amount of time for student-centered interactions in his SIMMS class as compared to his non-SIMMS class, 12% and 8% respectively (see Figure 9).

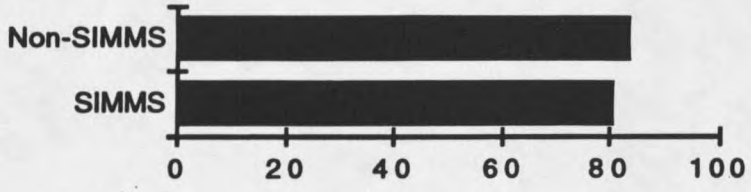


Figure 8. Adam's Use of Whole Class Instruction.

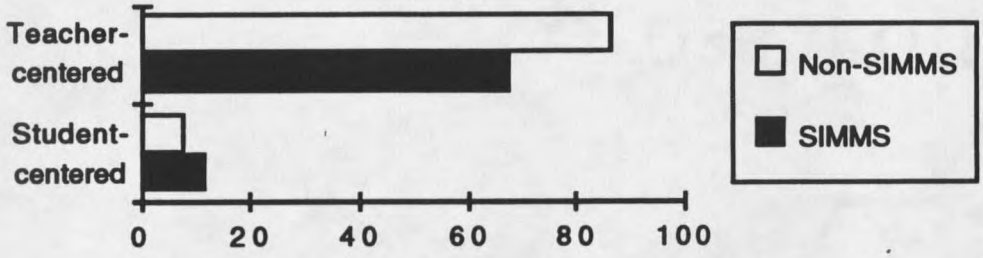


Figure 9. Adam's Coded Interactions.

In Adam's SIMMS class the student-centered interaction most prevalent was *encouraging discussion among students about problems(10)*. In the following vignette the students were working in groups entering data from a survey into a computer spreadsheet. One group had a survey form in which the person had marked two answers. Adam helped the students decide how to handle the situation.

Student 1: This guy marked both A and B.
Adam: That is something you guys are going to have to talk about as a group and decide. What are you going to do if somebody checks two things?
Student 2: This guy put both.
Student 3: Put a three for like -
Student 4: Couldn't it be - sometimes
Adam: What is the question?
Student 1: Do you get along with family members?
Adam: So if they put A and B does that mean "sometimes they do" and "sometimes they don't"?
Student 2: We could put like a C.

The interaction of asking *process-oriented questions (13)* was the most used student-centered interaction in Adam's non-SIMMS class. It was quite different from the process oriented interaction in his SIMMS class in that it was most often related to choosing the appropriate algorithm. While working problems at the board, he would ask students to supply the appropriate next step for the given problem. In the following vignette from the non-SIMMS class, Adam had called for questions on the assignment and a student had requested that he work problem number 14. Adam first wrote the problem on the board and then turned to the class.

Adam: OK, what are you going to do first?
Student: Subtract one.
Adam: Subtract one. Now?
Several students: Divide by three.
Adam: Divide by three. Now?
Several students: Square root.
Adam: Square root of both sides.

This interaction is not entirely student-centered as Adam repeated students' responses making them more complete, if needed.

The variety of student-centered interactions Adam used was consistent between his classes. However, he used fewer different student-centered interactions than the composite classes; he used six while there were eight different ones in the composite classes.

Differences in teacher-centered interactions between Adam's two classes mirrored those of the composite classes except for about a third more time being given to short answer questions. He used the short answer question format more than any of the other study teachers in both his SIMMS and non-SIMMS classes. Direct instruction in his SIMMS class took about half as much time as in the non-SIMMS class. Teacher-given directions were three times more common in the SIMMS class. The non-SIMMS class directions were usually short and to the point.

> Adam: OK, get out your work sheets Get into groups of no more than four. No more than four! Work on the ones you had trouble on, the ones you are struggling with. If you've got them all done that is great.

The SIMMS class directions were often more detailed.

> Adam: OK, a couple of things folks. First of all the file that you are going to do today on Excel, please call it 'p4g', your group number, and 'corr' for correlation. Now several different things we need to talk about. First of all you've got about five minutes here to meet in your groups, and each of you needs to say the two questions that you want to correlate. And then I want you to

rank them one, two, three, four. One meaning the one that your group would most like to correlate, two meaning second, three, and four.

Betty

Betty's use of whole group instruction in her classes matched that of the composite classes (see Figure 10). However, unlike the composite classes, she used student-centered interactions about 20% of the time in both classes (see Figure 11).

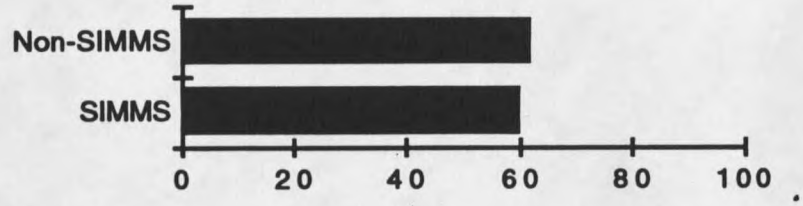


Figure 10. Betty's Use of Whole Class Instruction.

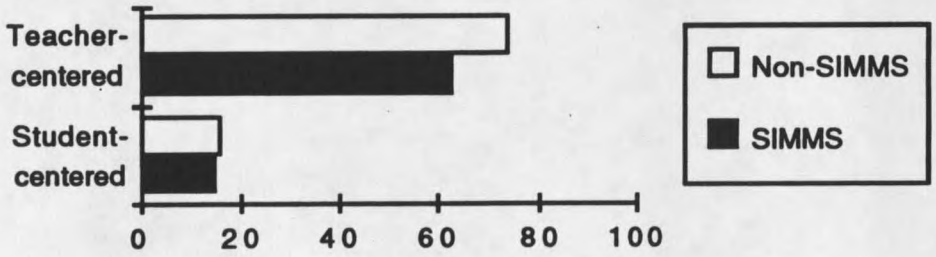


Figure 11. Betty's Coded Interactions.

The most frequently used student-centered interaction in her SIMMS class was *encouraging discussion among students about problems(10).* She would often ask for input from the class

members, rather than just "give the answer." For example, one day the SIMMS students were working on a set of questions and a student had trouble with one of them. Betty suggested ways to interpret the question, but he still did not understand what to do. Instead of giving him the answer, Betty suggested he work on other questions for a few minutes until the whole class could discuss it and solve the problem together.

> Student: I still don't get it.
> Betty: OK, we'll wait . . . because we [the class] are going to talk about these questions. Some of the groups will probably have some ideas.

The same type of interaction was frequently used in her non-SIMMS class, too. In the following excerpt from the non-SIMMS class, the students were working in groups on an exploratory assignment. Students were to explore relationships between the angles of a cyclic quadrilateral. Betty helped set the scene and then let the students discuss the problem.

> Betty: You've got them the same. Look at opposite angles. There is a relationship with the opposite angles. And you might look at his [another member of the group] data too.
> Student: They equal one eighty?
> Betty: Compare with him.
> Student: Is that true though?
> Betty: I'm not going to say. I'll let you decide.

Eight different types of student-centered interactions were used in both her SIMMS and non-SIMMS classes.

Teacher-centered interactions did occupy a little less of the instructional time in Betty's SIMMS class than in her non-SIMMS class, 60% as compared to 70%. Each of the types of interactions in this category had a somewhat smaller percentage in the SIMMS class, except for *teacher given directions (td)*, which had about the same proportion in both classes.

Carol

Carol spent a little over 40% of her instructional time in whole class situations in both her SIMMS and non-SIMMS classes. She spent less time in whole class situations than the composite classes (see Figure 12).

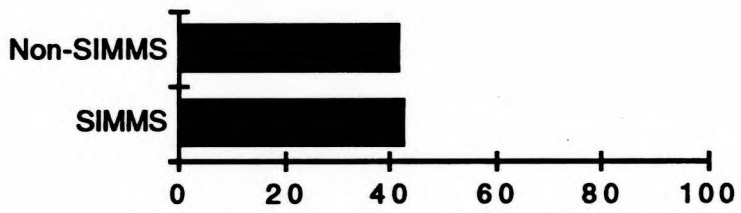


Figure 12. Carol's Use of Whole Class Instruction.

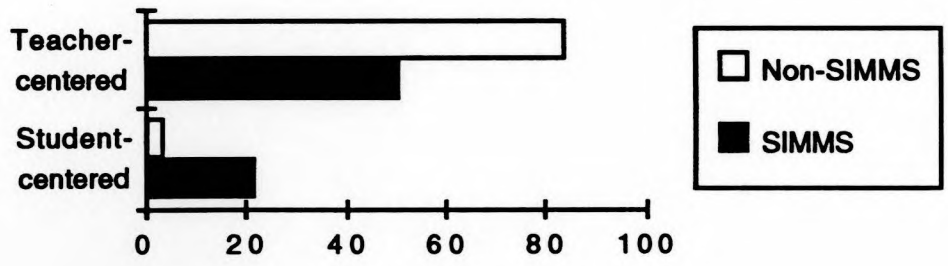


Figure 13. Carol's Coded Interactions.

There was a dramatic difference in the use of student-centered interactions between her SIMMS and non-SIMMS classes, 22% in the SIMMS class and only 4% in the non-SIMMS class (see Figure 13). Carol's most frequent student-centered interaction in both classes was *encourages discussion among students (10)*, although it was used twice as often in the SIMMS class compared to the non-SIMMS class. In the following example from her SIMMS class, Carol helps a group of students understand a question without telling them how to answer it.

Carol: If we put everybody's data together what would be a good way to do it [represent the data]? The same way [as before]?
Student: No, because we would have too many (recording unclear), wouldn't we?
Carol: I don't know. What would be a good way to organize the whole thing? That is what they are asking.

The following example of the same type of interaction is from the non-SIMMS class. The students were working at their tables on an assignment from the text. Carol stood by a group and let the students argue over a problem until they agreed upon an answer.

Student 2: Twenty-five over sixty-four, right?
Student 1: No.
Student 2: What do you got? Is it twenty-five over sixty-four?
Student 1: No, wait, it's sixty-four over twenty-five
Student 2: Is it?
Student 1: Is it sixty-four over twenty-five?
Carol: That's right.

Eight different types of student-centered interactions occurred in Carol's SIMMS class compared to four in her non-SIMMS class.

Teacher-centered interactions occupied quite different portions of the instructional time in Carol's classes, 84% in her non-SIMMS class and 50% in her SIMMS class. The *direct instruction (di)* percentage accounted for most of the difference with less than half as much time being devoted to it in the SIMMS class than in the non-SIMMS class. Carol spent almost three times as much time in *teacher given directions (td)* in the SIMMS class than in the non-SIMMS class, 27% as compared to 10%.

David

David had the largest difference in use of whole class instructional situations between his observed classes, less then 40% (note Table 2, page 137) in SIMMS class as compared to 60% in non-SIMMS class (see Figure 13). There was also a dramatic difference in his use of student-centered interactions, 25% in his SIMMS class as compared to only 2% in his non-SIMMS class (see Figure 14).

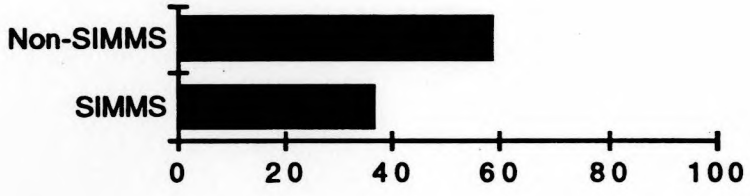


Figure 14. David's Use of Whole Class Instruction.

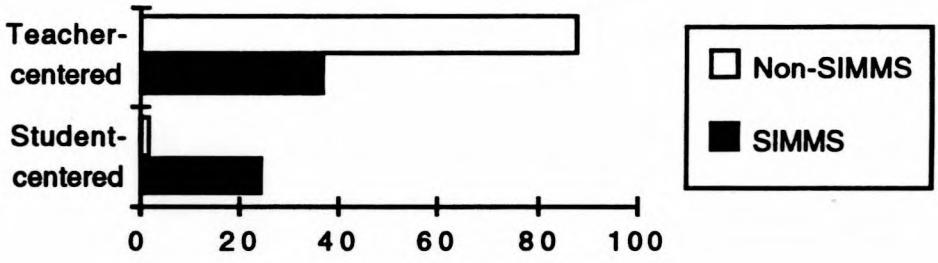


Figure 15. David's Coded Interactions.

Encouraging discussion among students (10) was the most frequent of any type of student-centered interaction. In this example from the SIMMS class, students had conducted an experiment on population growth using Skittles (skeeters) and M&M candies. The skeeters and M&M's were also referred to as rabbits and wolves. For one group the M&M's (wolves) died out. David helped them decide what the problem was and helped them consider different ways it could be solved.

Student 3: But, so what should we do now?
Student 2: Should we just go on?
David: Well, what do you think are some of the reasons that caused the M&M's -
Student 2: Not having enough skeeters.
David: OK, so what are some things that we could do to -
Student 3: We should start over -
Student 1: We should start with more than two skeeters in a container. We should start with four or five skeeters.
David: There's one good thing, is there something else you could do? Larry suggested starting with a larger initial population. What's something else you could do?

. . .
Student 2: Put them in closed - smaller area.
David: Put them in a smaller area. That's what this group over here did. They partitioned their box off.
Student 3: So are we supposed to make it so they can (recording unclear).
David: You can do whatever you want to do.

The interaction *moderating discussion on student generated ideas(15)* was next in frequency of use. The following exchange occurred during a whole class discussion in the SIMMS class. The students had been asked to suggest ways to display the data they had collected during the population experiment.

David: How could we display it, maybe?
Student 1: You could do a pictograph.
David: We could do a pictograph, maybe, and how would you organize the pictograph?
Student 2: How about the total at the end of the ten shakes. Like group one, their total at the end of the ten shakes and then group two.
David: Okay, other ideas on that? Mike what were you thinking?

Six different types of student-centered interactions were used in the SIMMS class as compared to three in the non-SIMMS class.

Teacher-centered interactions constituted less than half of his SIMMS class time, but almost 80% of the non-SIMMS class. Direct instruction constituted 24% of the instructional time in the SIMMS class and 64% in the non-SIMMS class. Teacher directions and short answer questions were also higher in the non-SIMMS class than the SIMMS class.

Changes in Classroom Interactions

Each of the study teachers was asked to reflect on changes in their classroom behavior as a result of the summer institute and the pre-piloting experience. All commented on the different classroom management style required by the SIMMS materials. They said the cooperative learning groups, frequent use of technology, and application-based content created a classroom that resembled a science laboratory more than a traditional mathematics classroom.

The constructivist theory basis of SIMMS materials caused the teachers to reflect on their approach to teaching. Carol expressed it in terms of the way she handled student questions.

> Carol: We [teachers] like to have all the right answers. When the kid asks a question, we like to be able to say, "Well, you should have done this." Getting in the habit instead of saying something like, "Well, back up to point A and look at this" and then just leave, walk off from the table and leave them alone and not give them a right answer was a change for me. I liked being able to tell kids the right answer. It makes you feel good because you think you're helping them. Here we're not telling them the right answer all the time and they have to fumble along on their own and that was a change for me.

David also commented on a shift of emphasis in his role in the SIMMS classroom. He appeared to no longer see himself as the central figure leading the students, but as a coach helping the students in their personal efforts.

> David: My role as a teacher has changed. With the [SIMMS] class it's more of an observer and a monitor rather than really an instructor. . . . I think that in the other classes that I teach, the traditional ones, I'm still more of a lecturer at times and a leader of discussion rather than someone that's monitoring and observing and trying to answer a few questions and get over the snags.

Both Carol and David were keenly aware of the differences in their behavior between their SIMMS and non-SIMMS classes. Carol seemed to feel the SIMMS materials enabled her to "allow" her students to struggle with a problem and try to construct their own meaning from the mathematical activity. She thought the traditional mathematics textbook structure required her to "give more answers," while the more open-ended SIMMS materials lent themselves to a variety of solutions.

> Carol: The kids will say, "What's the answer?". . . I can honestly say it, "There's not a right answer.". . . Because there's not a right one or a wrong one, that helps. The modules lend themselves to doing that.

Likewise, David seemed to attribute the difference in his SIMMS and non-SIMMS class to the structure of materials, and stated it in terms of student autonomy.

> David: I think it's because of the way the material is developed and the way it lends itself to be presented. In the traditional class, you develop a concept or two on a daily basis, you explain it to the students and then they practice it, where in the SIMMS material you don't. It's just a series of problems and question after question which I don't think needs too much introduction by the teacher. It just needs the students

> to think about it a little bit and pool all their knowledge with the people in their group and they're able to come up with some good solutions to different questions that arise.

Betty seemed to see her change in classroom behavior more in terms of the general pedagogy for all her classes. As the result of the summer institute, she said she tried to de-emphasize passive lecture situations and provide her students with more tasks that required active participation.

> Betty: I really realized the importance of more hands-on in the classroom. . . . I've gone a lot to hands-on and I'm finding that they like it better, which makes a whole bit of difference in how much kids will learn, if they like it. And then they are understanding what's going on and I think they're going to remember it. I think it's changed my views on teaching a lot. I also really see the benefit of cooperative learning. . . . Although I don't know if I like it every day, all the time.

Adam's comments on change seldom dealt with his own change process, but rather that of the students. He often ended up reaffirming his previous ideas. He noted that the pre-piloting had caused him to re-examine how students learned and that they did not seem to be doing well with the SIMMS constructivist format.

> Adam: I'm finding out very quickly how kids are learning math. They're learning it by watching what I'm writing on the chalkboard. They're not reading the books at all and they're not using their head at all. They're mimicking what they see. I've always thought that, in a way, but I never realized how strongly until now. These kids are lost without that.

Adam seemed to have reservations about the ability of ninth grade students' to learn mathematics via the SIMMS format.

Each of the teachers noted changes in their classroom interactions because of the SIMMS program, some in both type of classes and some only in the SIMMS classes. They often seemed to be trying to implement the SIMMS philosophy and become a facilitator of learning without a clear picture of what that entailed.

Study Teachers' Definition of Facilitator

"Facilitator of learning" was one of the terms discussed during the SIMMS 1992 Teacher/Leader Summer Institute to describe the behavior of a SIMMS teacher. It is a term which is used in NCTM, SIMMS and other educational literature to describe a teacher who interacts with his or her students in a student-centered manner. No specific definition was given by the institute leaders, but different types of facilitating teacher behaviors were discussed.

Some of the questions included in the third interview dealt with the teacher's perception of the classroom interactions of a facilitator of learning. Some common themes among the teachers' responses were "answering questions," "not giving answers," "asking leading questions," "getting discussion started," and "giving direct instruction."

The first two items seem to be contradictory, but more careful study of the interview statements reveal that "answering questions" refers to giving technical assistance and/or clarifying directions. These interactions were often very directive.

> Adam: When the kids are working in groups, all you're doing is answering their questions so they can keep going.
>
> Carol: In the SIMMS classes? I would say probably 80 to 90% of the time I'm just answering questions.
>
> David: Someone that's monitoring and observing and trying to . . . answer a few questions and get over the snags.

"Not giving answers" was a recurring topic of discussion during the summer institute. Teachers were unsure of how much to let the students struggle and how much direct assistance to give. They wanted to let the students figure things out for themselves, but were afraid too much frustration might cause them to give up.

> David: I try not to answer too many of their questions with just outright answers. I think I've always done that to a certain degree, but I guess I've been more aware of it with the SIMMS work.
>
> Carol: In SIMMS I don't give them the answer right away. It's a lot easier there [in the SIMMS class]. Part of the reason is the way the questions are written. It's a lot easier to say, "Well, just go back and read the first sentence again and think about it and if you still have a question, I'll come back in a little bit."

Leading questions were seen as a way to respond to student questions without "giving them the answer." They wanted to give the students a "push" in the right direction and then let them continue on their own.

> Betty: When a group is in a situation where you can give lead[ing] questions without giving answers . . . ask a question that makes you think about it in a different way.

> David: I have a little more experience and expertise and can help them or guide them, or show them places where they can find answers to their solutions. Not give them answers, but kind of help them. Give them directed questions, maybe you can guide them to a response that they might be comfortable with.

The leading questions took many forms from a sequence of questions that led the student to the "correct" answer in small steps, to bringing up evidence that conflicted the students' solution and letting them rethink their solution.

The role of a facilitator of learning as a coach or guide was mentioned by most of the teachers. They seemed to see themselves as a support person to help the students become persistent in their problem solving.

> David: I guess a facilitator would be kind of a person that organizes and kind of guides and paces you. Tries to make sure you're staying on task.

> Adam: Their role is to get the discussion started. But then once it's started to stand back and allow the discussion to go on between the participants . . . you are there to make sure the discussion stays focused."

The lecturer role was not abandoned. Adam, Betty, and Carol mentioned direct instruction as part of the facilitator picture. They felt that certain topics could be best handled in this format.

> Adam: Like mean, median and mode, the only way it got in there [SIMMS class session] is because they asked a question on whether it was the mean or the median so I just did a little mini-lecture on mean, median and mode.
>
> Betty: And I do think too, that you need instruction, and I think the kids aren't going to just pick this up through the material. I think there has to be some. Maybe it's my group of kids, but there still has to be some, this is what's going on here and this is how you do this and that kind of thing.
>
> Carol: There are times in SIMMS where I've spent time in a lecture mode. You just have to back up and say, "Wait a minute. There's some background stuff you need to know before we can do this."

The role of a facilitator of learning is often described in vague terms in educational literature. The study teachers had to decide what it meant for them and try to put it into practice. Their definitions were very similar, however the way they implemented it in the classroom was quite different, as was evident from the classroom transcripts.

Teachers' Concerns and Innovation Acceptance

While the study teachers seemed to embrace the SIMMS project and its constructivist philosophy, they all expressed concerns about the changes in curriculum and methodology it was advocating. The Research and Development Center for Teacher Education in Austin Texas, developed a list of seven typical stages of concern teachers express about an educational innovation, (see page 22) (Newlove, 1976). Comparing concerns that teachers express during the personal interviews may help in understanding their position with respect to the SIMMS program and philosophy. This provides one additional piece of information to help interpret a teacher's classroom interactions.

None of the teachers expressed concerns in stage 0 (awareness) and stage 1 (informational) during the interviews. They knew they were going to be pre-piloting the SIMMS program at the time they were chosen to attend the 1992 SIMMS Teacher/Leader Summer Institute. The initial stage concerns were addressed during the institute. The concerns expressed during the interviews covered stage 2 (personal) through stage 5 (collaboration) with the lower numbered stages more prevalent in the earlier interviews.

Adam

During the first interview Adam seemed very tense when discussing problems in his SIMMS classes. His comments were

mainly in stages 2 or 3 and were concerned with his ability to organize and present the material appropriately.

> I think the hardest thing for me is the prep time. I mean, every day is a lab in there. You've got to have this and that and the other thing and its really hard to get it all.

A month later during the second interview his concerns were at stages 3 or 4, with statements about the structure of the SIMMS program and his students' reaction to it.

> I think we have gone too far the other way. We went from this traditional "Here's your book. Here's your lecture. Do your assignment" completely to application based. Everything is application. I want a mix of the two.

He was concerned that his students seemed to be having trouble adjusting to the different structure and expectations.

> They absolutely refuse to read and go through steps. They want to be told.

The third interview was near the end of the first semester and Adam was much calmer in his discussion of concerns about SIMMS. The focus of his concerns were, however, still in stages 3 and 4 with the SIMMS program structure and its effect on his students.

> I think things are going smoother. I think I'm more comfortable with some of it. I wish I had more direction. [For example] in the Skeeter module, what exactly are the kids supposed to get out of it?

> If, by the end of the four years, SIMMS gets the math done too, I think it'd be incredible. . . . I'm wondering what's ahead and whether they're going to learn all that [concepts needed for further courses] and whether they're going to get all that.

Betty

The first interview with Betty focused on stage 2 concerns, personal ability to meet new demands, as it had with Adam.

> I wish I had ideas on it [cooperative learning] . . . tricks of the trade. . . . When a group isn't functioning well, what are some things you can do?

> I was shoving them [non-SIMMS classes] all aside so that I could spend all this time on SIMMS, and I just thought it wasn't fair.

Betty's second interview focused on her concern about the impact of SIMMS on her students, stage 4. She could see both good and bad implications.

> From what I've seen [SIMMS] isn't going to prepare them for a strenuous college calculus course, but I haven't seen any of the advanced - the other year's stuff. I know from what they've learned this year, they haven't learned anything like how to manipulate equations and things. I know everyone's saying that's not important. But it is if you go into calculus.

> I do think these kinds of kids [low level] learn better in this kind of situation. . . . For the first time in a lot of their lives, mathematics is fun and they're enjoying it.

Concerns voiced during Betty's third interview ran the gambit from stage 2 (personal) to stage 4 (consequences). She

commented on the frequent use of cooperative learning groups and her changing role in light of that.

> That's probably my biggest complaint with SIMMS, . . . I just don't think that you need to be in groups every moment.
>
> There are a lot of days, once I get them to working, where they all just work away and I just kind of feel lost. They don't need me.

Because of the low ability level of her students, their performance with the SIMMS materials was a major concern.

> I think they have a higher frustration level because they're not getting [understanding] all the mathematics. I don't know if that's the material or the kids, and I really think it's more the kids because the kids in the SIMMS who are brighter kids [in other classes] are doing okay with the material.

Carol

Stage 2 (personal) was a theme for Carol's first interview as it was with the others. In spite of her experience with the modules in the summer institute, she was surprised by the science lab management skills they required.

> I was amazed at the management skills of trying to keep track of the material. My managerial skills as a science teacher aren't good. And I need to work on that real bad.

Stage 4 (consequences) concerns about her students were another theme in the first interview. She saw definite advantages for the

low ability students, and was guardedly optimistic about the gifted students.

> It was fun to watch kids when they got into it. It was impressive because some of the kids who are normally not involved and the slower kids really got into the Cars module. . . . We're going to turn on a lot of non-traditional students that used to not like math at all. It's going to be real exciting. I hope we don't lose any of the ones that liked it before. I don't think we will, but I hope we don't. That would be the negative side.

Carol's second interview echoed the same stages of concern as the first. She was uncertain about the added personal demands of pre-piloting a new program.

> It's hard to teach a class that's never been taught by anybody before. It's really scary at times. . . . The amount of paperwork that we're doing, along with trying to teach the new class and find all the new materials is just overwhelming.

She did see some positive results for her students beyond the mathematics they were studying.

> I think it's forced those kids to become more social and to have to work with other people, like they're going to have to do when they get out in the real world. So, I think it's been real beneficial to those kids.

Stage 4, concern for her students, was also a theme during Carol's third interview. She wanted to be sure the students were learning the mathematics they would need.

> I've got one real positive thing to say about the class. Every time I see a parent of anybody from SIMMS I say, "Well, what does your son or daughter say about the

> class?" . . . Almost all of them say they like it, but I was still concerned about if the kids really think they're getting their math, or if they just like it cause it's fun. They get to do stuff that they've never done in math before.

David

David's personal concerns were at stage 3 (management) during his first interview. He was concerned about how to manage his class time most efficiently.

> You learn a lot just by experimenting . . . but maybe we can cut down on some of that fumbling along here by spending more time [in the summer institute] actually delving into the things, software, the computers and understanding them a little bit better.

Unlike the other teachers, David quickly moved on to focus on stage 5 and 6 concerns. He expressed the desire to collaborate with other pre-piloting teachers and generate alternative pedagogy.

> Something that we could work harder on next summer is some more cooperative grouping techniques and how to evaluate, manage the groups and things like that. I think you [teachers] have a lot of ideas and then each person can come up with their own guidelines that they want to implement.

During the second interview, David re-expressed stage 3 classroom management concerns.

> I guess some ways I feel like I'm back pedaling or on my heels a lot because I'm not sure a lot of times how much . . . to interfere and how much just to let them work [in their groups].

Concern for his students, stage 4, was consistently mentioned with guarded optimism.

> I think a lot of it's good, so it's a good change . . . if we will have all the math taught that they need to do well on the SATs and ACTs and be ready to college. . . . When they hit that freshman college math class, how are they going to be prepared?

Again David was unique in his mention of stage 5 or 6 concerns. He expressed a desire to collaborate with other SIMMS teachers and generate ideas which each teacher could modify to their own needs.

> I think that if we can get through all the people that use it this year, if we can put together some things [on alternative assessment] that would be useful and get that out to the people who will be trying to teach it. They could get some ideas and then alter it to meet their needs because I think that's one of the big concerns is trying to figure it out, how to evaluate it effectively. Give them a lot of ideas and then you can pick and choose and use the things that they feel are maybe going to work for them.

During the third interview David reiterated his concerns about his classroom role, stage 3, and the impact of SIMMS on his students, stage 4.

> There's times when I get kind of discouraged with it . . . I start thinking, "Boy, it would sure have been a lot easier if we were doing it the old way." But then I stop and think about what our goals and what our philosophies are. . . . I have [twenty kids] in here right now, hopefully by the time they're seniors, I'll still have twenty kids in here. . . . That's what I'm hoping for.

He summed it up with, "A lot of it is, I think, I don't know quite how to act."

Even though David was the only one to express stage 5 or 6 concerns about collaboration and refocusing, all of the teachers did engage in collaborative and refocusing activities the summer following their pre-piloting experience, either at a SIMMS Institute or as a graduate student in mathematics education. All of the study teachers have continued their association with the SIMMS project and field tested the program during the 1993-1994 school year.

Summary of Findings

All of the study teachers were enthusiastic about the SIMMS project and in general agreement with its philosophy. The expressed concerns ran the gambit from worries about collecting materials for experiments to desires to pool everyone's experience and redefine the classroom norm. However, the majority of concerns expressed during interviews did not go much beyond the surface details of managing the classroom.

The percentage of student-centered and teacher-centered interactions remained consistent for each teacher whether measured over all of the class sessions, over whole class situations, or over small group situations. This was true for SIMMS and non-SIMMS classes alike.

All of the study teachers used more student-centered interaction in their SIMMS class than non-SIMMS. Most of them used more of a variety of student-centered interactions in their SIMMS classes as compared to their non-SIMMS classes.

The amount of time devoted to student-centered interactions varied widely among the study teachers as well as between SIMMS and non-SIMMS classes. Betty used similar interactions in both SIMMS and non-SIMMS classes, while the other teachers used at least double the percentage of student-centered interactions in their SIMMS classes as in their non-SIMMS classes The most dramatic difference was between David's SIMMS and non-SIMMS classes.

The study teachers' definition of facilitator of learning was vague at best. They seemed to be trying to integrate what they had always done in their classroom with what they understood the SIMMS constructivist philosophy to be.

The teachers took about three times as long to give directions in the SIMMS classes as they did in the non-SIMMS classes. The directions for the SIMMS classes were also more detailed.

Group instruction is an essential part of the SIMMS program. Yet, there was a big difference in the amount of time devoted to small group instruction among the study teachers' SIMMS classes. All of the study teachers expressed concerns about cooperative learning groups and the most effective way to manage them.

CONCLUSIONS

Discussion and Recommendations

The findings of this study will be discussed under the following headings: Constructing a New Teaching Philosophy, Translating Theory into Practice, Patterns of Interactions, Differences in Interactions, Detriments to Teacher Change, Professional Development Considerations, and Classroom Organization. These are not distinct divisions, so some of the ideas will overlap.

Constructing a New Teaching Philosophy

Teacher-student interactions based on constructivist theory represent a change in classroom behavior for many teachers. A model for the way teachers learn and understand these different teaching behaviors is also found in constructivist theory. Teachers need to understand the theoretical foundations of constructivism in order to implement the related methodology in their classrooms. Teachers' classroom behaviors are shaped by previous experiences (both as a student and as a teacher) and their perceptions of what will achieve instructional and behavioral goals. The mathematics education community is now trying to

change these goals (National Council of Teachers of Mathematics (NCTM) Curriculum and Evaluation Standards for School Mathematics) and how the goals ought to be achieved (NCTM Professional Standards for Teaching Mathematics). Constructivist theory says that teachers need to experience new ideas in an environment in which they can construct their own interpretation of the idea's place in their classroom.

The teachers need to experience the mathematics much as their students will and then reflect on their own thinking processes. The teachers who participated in the Systemic Initiative for Montana Mathematics and Science (SIMMS) 1992 Summer Teacher/Leader Institute kept personal journals. They recorded their thoughts about, and reactions to, the SIMMS modules, teaching American Indian students, and various institute "workshop" sessions. The entries, however, were often about superficial details of organization rather than reflections on their thinking processes. This pattern was continued in the 1992-1993 pre-piloting of the SIMMS program as indicated by the teachers' expressions of concern about the project. They seemed to focus on administrative details and ignore the philosophical underpinnings. Teachers who have rarely been asked to reflect on their own thinking processes may need help in getting started. The clinical interview techniques used by psychologists have been found to be useful in helping teachers probe student thinking. Experience with these techniques may also help teachers as they examine their own

thought processes (Konold, 1986). Another suggestion is to read and discuss current education literature such as Inquiring Teachers, Inquiring Learners: A Constructionist Approach for Teaching by Catherine Fosnot or Reconstructing Mathematics Education: Stories of Teachers Meeting the Challenge of Reform by Deborah Schifter and Catherine Fosnot

Translating Theory into Practice

After reflecting on their own thinking processes, teachers can explore pedagogy which will facilitate the students' thinking and learning as the students work through the same or similar curricular materials. This is a very important extension of the reflection process. The social process of discussion helps teachers solidify their ideas about the learning process and plan specific actions and interactions to use in the classroom. While the teachers who participated in the 1992 Summer Institute enjoyed working through the modules, they tended to view the modules from a teacher-centered perspective. Instead of considering various teacher-student interactions which would help students construct their own understandings, the teachers often tried to encapsulate the material for the students as they had previously been expected to do with more traditional texts.

Helping the teachers focus on their own learning processes may assist them in finding ways to facilitate students' work. Inservice and preservice time must be given to exploring constructivist learning theory and helping the teachers construct

their own understanding of it so they can translate it into classroom interactions. There is a growing body of research about the ways teachers change their classroom behavior. Curricular reform projects, such as SIMMS, should have someone knowledgeable in the field of teacher change to assist them in professional development efforts.

Patterns of Interactions

The researcher's bias statement (see page 33) expressed the view that teachers will tend to use the same pattern of interactions in all their classes. This expectation was partially borne out in the finding of consistency in interaction usage across whole class and small group structures. The percentage of time spent in either student-centered or teacher-centered interactions was consistent whether figured over the class as a whole, over whole class situations only, or over small group settings only.

The small group learning structure was a major component of the SIMMS approach to teaching. It was assumed this structure would necessitate the use of more student-centered interactions. The findings for this study do not support this idea. The grouping structure seemed to have little effect on the way the teachers interacted with their students. If they tended to use direct instruction in a whole class situation, they also tended to use direct instruction when interacting one on one or in small groups.

This is a significant finding, as it indicates that simply changing the structure of the learning environment does not change

the way teachers interact with their students. If an educational goal is more student-centered teaching, then teacher educators will have to assist the teachers in learning how to interact in more student-centered ways. Modeling student-centered interactions during inservice and preservice workshops and then having the participants reflect on the pedagogy just experienced is one way to make the participants more aware of teacher-student interactions and their effect on the students.

In this study there was evidence that some teachers who completely embrace the SIMMS philosophy will try to use the accompanying pedagogical ideas in all of their classes. After all, if the pedagogical approach advocated by the project is perceived to be sound, then it should be used for all the classes, not just the experimental ones. Betty, one of the four teachers studied, spoke of trying to change the way she taught in all of her classes to enable all of her students to construct their own meanings from mathematical activities. She endeavored to spend less time lecturing, give more group work, assign more "discovery-type" lessons, and use technology when appropriate. While she did not use student-centered interactions as much as some other teachers, she was consistent in their use across all of her classes.

Differences in Interaction Patterns

Evidence from this study indicated that most of the study teachers did not use the same pattern of interactions in all of

their classes. They used student-centered interactions more often in their SIMMS classes than their non-SIMMS classes. They also used a wider variety of student-centered interactions in their SIMMS classes. They may have been more conscious of using student-centered interactions in the SIMMS class because they were aware of participating in an experiment and wanted to do their best to follow the SIMMS philosophy. David, for example, commented on consciously trying to do things differently in his SIMMS class. The SIMMS classes were videotaped more often than the non-SIMMS classes as other SIMMS personnel were using them as feedback about the modules. Having classroom interactions taped may have made them more conscious of being a facilitator.

Another factor influencing the increased use of student-centered interactions in SIMMS classes may have been that the SIMMS curricular materials were structured for a constructivist teaching methodology. The materials presented some non-standard problem situations in which there was no one "right" answer, so the teacher could honestly say, "Let's explore it together." The materials were designed to ask more constructivist questions helping the teachers to interact in more student-centered ways. It would appear that having well written curricular materials that follow the constructivist philosophy may be central to student-centered teaching.

Detriments to Change

Curricular materials are a major factor in determining teacher instructional behavior in more than just the SIMMS classes. Much of the classroom instruction in this country is structured around a textbook rather than a philosophy of learning (Shavelson, 1983; Ysseldyke, Thurlow, & Christenson, 1987). The SIMMS project prepared curricular materials geared to promote a social constructivist classroom environment. They required the students to take an active role in their learning. All of the study teachers agreed this was a desirable goal for all of their students, not just the ones in the experimental class. However, no matter how much the teachers may have agreed with the philosophy, they often felt they did not have the time to create, or even look for, other materials which presented the non-SIMMS textbook topics in a format more in keeping with the SIMMS philosophy.

David spoke of the benefits of the SIMMS methodology, but he did not feel that his traditional text allowed him the freedom to use it in his non-SIMMS classroom. Carol was also very open in admitting that the textbook structured her classrooms. The SIMMS materials seemed to make it easier for the teachers to use more student-centered interactions. If student-centered interactions are a goal of the SIMMS program, well written curricular materials which help students take charge of their own learning and allow teachers to be facilitators are essential.

Teacher burn-out may have been another factor which contributed to different interactions in SIMMS and non-SIMMS classes. All of the study teachers commented on the amount of time it took to prepare for the SIMMS classes. The need to gather items for laboratory type assignments in the modules added to the preparation time. "Grading" the essay type assignments was also time consuming. With the pre-piloting taking so much time, it was just easier and more familiar to follow previously established patterns of behavior in the non-SIMMS classes.

Professional Development Considerations

A professional development problem which surfaced during this study was that of teachers having only a "negative" role model. They seemed more sure of what they were not supposed to do rather than what they were supposed to do. They spoke in terms of not doing things, such as not lecturing, not always answering student questions directly, and not assigning drill sheets. This study indicated that if teachers are going to be expected to modify their teaching behaviors and beliefs, they must helped to understand what the new idea is "for" not just what it is against. As John Dewey remarked in Experience and Education (1939), "a philosophy which proceeds on the basis of rejection, of sheer opposition, will neglect these questions [how to organize the new pedagogy]" (p. 21).

At the time of the 1992 Summer Teacher/Leader Institute, the SIMMS philosophy had been developed using the general concepts embodied in pedagogy recommended by the NCTM Professional Standards for Teaching Mathematics. Since the SIMMS program was new and untested, it was easier to discuss what had not worked up to now rather than give specifics on what to do with the new curriculum, which was at that time only in draft form. The institute leaders presented the general SIMMS philosophy and then depended on the pre-piloting teachers to translate it into classroom practice.

The teachers were asked to be facilitators of learning rather than "traditional" teachers; however, no specific definition of facilitator of learning was given, nor any guidelines for the amount of instructional time they were expected to be a facilitator. Many of the teachers seemed to feel they should be a facilitator all the time. Therefore, the description of a facilitator which emerged from the interviews included all of the ways the teachers previously interacted with their students plus their interpretation of constructivist methodology. What is a facilitator of learning? How much instructional time should be spent being a facilitator? What are the short- and long-term benefits? What are the drawbacks? All of these questions need to be thoroughly discussed with teachers who will be teaching the SIMMS program. Further research on the role of a facilitator of

learning is important for mathematics teacher educators both in and out of the SIMMS project .

Classroom Organization

A surprising finding of this study was the amount of instructional time teachers spent in giving directions in the SIMMS classes. Teacher-given directions were three times more common in SIMMS classes than non-SIMMS classes. Three factors may have contributed to this seeming proliferation of directions. (1) The students are being asked to do more complicated tasks than in non-SIMMS classes. The traditional assignment consisted of doing some problems at the end of the textbook section, while the SIMMS students were asked to conduct experiments, collect data and try to find a pattern. (2) The SIMMS students were not used to reading and following involved directions. Traditionally high school students are seldom asked to read their mathematics textbook. Students should develop this ability as they move through the SIMMS program levels. (3) The SIMMS modules were in draft form and some of the directions may not have been very clear. As the teachers monitored the progress of student activities, the teachers often helped the students decipher the written directions. The amount of time given to directions is a phenomenon worthy of further study as the revised SIMMS materials are field tested.

The use of cooperative learning groups was a major component of the SIMMS program. While most of the study teachers had used group learning in their classrooms before, all

agreed that the SIMMS cooperative learning groups worked differently in that the students really needed to work together to complete an activity, rather than just all doing the same problems and then checking answers. Much of the conversation at the SIMMS Teacher/Leader two-day support conferences in 1992-1993 was on ways to organize and interact with cooperative learning groups. How do you prepare your students to work in groups when they haven't done that before? How do you establish positive interdependence and yet retain individual accountability? All of the pre-piloting teachers, including the four in this study, requested assistance in finding group-building activities in addition to the content activities already in the modules. The SIMMS students did learn to work together better as the school year progressed, but the teachers felt their classroom time could have been more productive if they had been able to help the students learn to work cooperatively more quickly.

Cooperative learning has been proven to be a beneficial instructional strategy, if implemented properly. However, teachers who are learning to structure a mathematics classroom around cooperative learning groupings need information on research results and time to practice, along with lots of patience and support from SIMMS personnel, teacher colleagues, and school administrators. The SIMMS Teacher/Leader Summer Institute included a short workshop on the theory and strategies of cooperative learning as well as experience working in groups

during the six weeks. But the pre-piloting teachers discovered they needed more specific information about and practice in managing a cooperative learning environment. Working in groups with peers is a different experience than facilitating the interactions of groups of teenagers. Guidelines for the frequency of use of cooperative learning groups in the SIMMS program framework would also assist the teachers as they implement the new classroom format.

Discussion Summary

This study gathered data with respect to patterns of the teacher-student interactions of teachers who were implementing a new curriculum. Change is a slow process and the SIMMS teachers have taken the first steps toward a different way of interacting with their students. They seemed to feel the constructivist-based SIMMS project holds a promise of more meaningful learning for their students. However, if teachers are to use the SIMMS recommended social constructivist methodology in their classrooms, they must be given the opportunity to explore its foundations as well as its translation into specific classrooms interactions.

A major influence on the use of student-centered interactions seemed to be the SIMMS program with its constructivist-based curricular materials. Three of the four

teachers used more student-centered interactions in their SIMMS classes than their non-SIMMS. Quality curricular materials based on constructivist ideas seem to make a difference in the way teachers and students interact. But curricular materials are just one piece of the picture. Teacher educators need to look for ways to help mathematics teachers learn to interact with their students in ways that will help the students construct their own understanding of mathematics, i.e., to be a facilitator of learning.

Previously new curricular materials have left much of the classroom implementation up to the individual teacher. The SIMMS program requires the teachers to use cooperative learning groups and technology as an integral part of the program. Teachers need support and continuing training in these areas.

Areas for Further Research

1. Do teachers interact differently with their students after the second and/or third year of teaching the SIMMS program? Continuing investigation of the phenomenon of teachers implementing the SIMMS program is important.

2. How much of classroom time should be devoted to student-centered teaching in a social constructivist environment? This study noted a wide range of usage of student-centered interactions from teachers who were using the same curricular materials.

3. Is there a difference in the quantity or quality of student talk in classroom with different amounts of time spent in student-centered teaching?

4. What is the effect of student-centered interactions on student-student interactions? This study focused on teacher-student interactions, but student-student interactions in SIMMS and non-SIMMS classrooms are another part of classroom interactions that should be investigated.

5. What differences, if any, are there between the teachers' statements about their teaching philosophy and their classroom interactions? Teachers who have attended workshops and institutes often know the "right things to say." Are these ideas just theories or are they being translated into classroom interactions?

6. What is the impact of various types of mathematics curricular materials on teacher-student interactions?

7. What are the most effective inservice techniques which will change teacher beliefs and actions from teacher-centered to student-centered?

REFERENCES CITED

Agatucci, C. (1989, March). Empowering students through collaborative learning strategies. Paper presented at Annual Meeting of the Conference on College Composition and Communication, Seattle, WA. (ERIC Document Reproduction Service No. ED 303 807)

Amidon, E. J., & Flanders, N. (1967). Interaction analysis as a feedback system. In E. J. Amidon & J. B. Hough (Eds.), Interaction analysis: Theory research and application. (pp. 121-140) Reading, MA: Addison Wesley.

Baird, J., & White, R. (1984, April). Improving learning through enhanced metacognition: A classroom study. Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA. (ERIC Document Reproduction Service No. ED 249 250)

Ball, D. L. (1989). Breaking with experience in learning to teach mathematics: The role of a preservice methods course. East Lansing, MI: National Center for Research on Teacher Education. (ERIC Document Reproduction Service No. ED 318 696)

Baroody, A., & Ginsburg, H. (1990). Children's learning: A cognitive view. In R. B. Davis, C. A. Maher & N. Noddiz (Eds.), Constructivist views on the teaching and learning of mathematics. Journal of Research in Mathematics Education. Monograph 4 (pp. 51-64). Reston, VA: National Council of Teachers of Mathematics.

Bauersfeld, H. (1988). Interaction, construction, and knowledge: Alternative perspectives for mathematics education. In D. A. Grouws & T. J. Cooney (Eds.), Perspectives on research on effective mathematics teaching: vol. 1 (pp. 26-46). Reston, VA: National Council of Teachers of Mathematics, .

Beal, J., Dolan, D., Lott, J., & Smith, J. (1989). Integrated mathematics: Definitions, issues, implications: Executive summary. Missoula, MT: Montana Council of Teachers of Mathematics.

Beardsley, M. C. (1960). The European philosophers from Descartes to Nietzsche. New York: Random House.

Bogdan, R. C., & Biklen, S. K. (1992). Qualitative research for education. Boston, MA: Allyn and Bacon.

Boyd, W. (Ed.). (1956). The EMILE of Jean Jacques Rousseau Selections. Columbia University, NY: Teachers College Press.

Chismar, C. (1985). Teacher meaning and student learning: The role of interaction in selected college classrooms. Lakewood, NJ: Georgian Court College. (ERIC Document Reproduction Service No. ED 269 763).

Cobb, P., Wood, T. , & Yackel, E. (1990). Classrooms as learning environments for teachers and researchers. In R. B. Davis, C. A. Maher & N. Noddiz (Eds.), Constructivist views on the teaching and learning of mathematics. Journal of Research in Mathematics Education, Monograph 4 (pp. 125-146). Reston, VA: National Council of Teachers of Mathematics.

Cobb, P., Wood, T., Yackel, E., Nichols, J., Wheatley, G., Trigatti, B., & Perlwitz, M. (1991). Assessment of a problem-centered second grade mathematics project. Journal for Research in Mathematics Education, 22(1), 3-29.

Confrey, J. (1990). What constructivism implies for teaching. In R. B. Davis, C. A. Maher & N. Noddiz (Eds.), Constructivist views on the teaching and learning of mathematics. Journal of Research in Mathematics Education, Monograph 4 (pp. 107-122). Reston, VA: National Council of Teachers of Mathematics.

Davidson, N. D. (1990). Small-group cooperative learning in mathematics. In T. J. Cooney & C. R. Hirsch (Eds.), Teaching and learning mathematics in the 1990s (pp. 52-61). Reston, VA: National Council of Teachers of Mathematics.

Davis, R. (1990). Discovery learning and constructivism. In R. B. Davis, C. A. Maher & N. Noddiz (Eds.), Constructivist views on the teaching and learning of mathematics. Journal of Research in Mathematics Education, Monograph 4 (pp. 93-106). Reston, VA: National Council of Teachers of Mathematics.

Davis, R., Mayer, C. & Noddings, N. (1990). Suggestions for the improvement of mathematics education. In R. B. Davis, C. A. Maher & N. Noddiz (Eds.), Constructivist views on the teaching and learning of mathematics. Journal of Research in Mathematics Education, Monograph 4 (pp. 187-191). Reston, VA: National Council of Teachers of Mathematics.

Dewey, J. (1939) Experience and education. New York: Macmillan Publishing Company.

Erickson, F., & Mohatt, G. (1982). Cultural organization of participation structures in two classrooms of Indian students. In G. Spindler (Ed.), Doing the ethnography of schooling: Educational anthropology in action (pp. 132-174). New York: Holt, Rinehart and Winston.

Ernest, P. (Ed.). (1989). Mathematics teaching: the state of the art. Bristol, PA: Falmer Press.

Firestone, W. A., & Dawson, J. A. (1981). To ethnograph or not to ethnograph? Varieties of qualitative research in education. Philadelphia: Research for Better Schools, Inc. (ERIC Document Reproduction Service No. ED 222 985)

Fosnot, C. (1993). Inquiring teachers, inquiring learners: A constructionist approach for teaching. New York: Teachers College Press.

Fullan, M (1991). The new meaning of educational change (2nd ed.). New York: Teachers College Press.

Furth, H. G. (1969). Piaget and knowledge. Englewood Cliff, NJ.: Prentice Hall.

Hall, G. E., & Rutherford, W. L. (1976). Concerns of teachers about implementing the innovation of team teaching: Procedures for adopting educational innovations project. Austin: Texas University. (ERIC Document Reproduction Service No. ED 128 930).

Heck, S., Steigelbauer, S., Hall, G., & Loucks, S. (1981). Measuring innovation configurations: Procedures and applications. Austin: University of Texas. (ERIC Document Reproduction Service No. ED 204147)

Higgins, K. (1987). Adolescent self-esteem and the schools. (ERIC Document Reproduction Service No. ED 312 528)

Hord, S. H. & Loucks, S. F. (1980). A concerns based model for the delivery of inservice. Austin, TX: Research & Development Center for Teacher Education. (ERIC Document Reproduction Service No. ED 206 620)

Jacob, E. (1987). Qualitative research traditions: A review. Review of Educational Research, 57(1), 1-50.

Kelly, J. (1985). Student-centered teaching for increased participation. Washington, D. C.: National Education Association. (ERIC Document Reproduction Service No. ED 260 033)

Kilpatrick, J. (1992). A history of research in mathematics education. In D. A. Grouws (Ed.), Handbook of research on mathematics teaching and learning (pp. 3-38) New York: Macmillan Publishing company.

Knight, J. (1987). Educational excellence and equity. Monograph v 2, n 4. Columbus, OH: Center for Sex Equity. (ERIC Document Reproduction Service No. ED 305 584)

Konold, C. (1986). Evaluating and modifying a teaching assistant training program for a workshop-style mathematics course: Final report. Amherst: University of Massachusetts. (ERIC Document Reproduction Service No. ED 299 156)

Kouba, V. L. (1991, April). The making of meaning: A model for interpreting mathematics education research. Paper presented at the Annual Meeting of the American Educational Research Association , Chicago, IL. (ERIC Document Reproduction Service No. ED 335 214)

Marias, J. (1967). History of Philosophy. New York: Dover.

Mathematical Sciences Education Board. (1991). Counting on you: Actions supporting mathematics teaching standards. Washington, D. C.: National Academy Press.

Mehan, H. (1982). The structure of classroom events and their consequences for student performance. In P. Gilmore & A. A. Glatthorn (Eds.), Children in and out of school: Ethnography and education (pp. 59-87). Washington, D. C.: Center for Applied Linguistics. (ERIC Document Reproduction Service No. ED 216 554)

National Council of Teachers of Mathematics. (1989). Curriculum and evaluation standards for school mathematics. Reston, VA: National Council of Teachers of Mathematics.

_____. (1991). Professional Standards for Teaching Mathematics. Reston, VA: National Council of Teachers of Mathematics.

National Research Council. (1989). Everybody counts: A report on the future of mathematics education. Washington, DC.: National Academy Press.

Newlove, B. W., & Hall, G. E. (1976). A manual for assessing open-ended statements of concern about an innovation. Austin: Texas University Research & Development Center for Teacher Education. (ERIC Document Reproduction Service No. ED 144 207)

Noddings, N. (1990). Constructivism in mathematics education. In R. B. Davis, C. A. Maher & N. Noddiz (Eds.), Constructivist views on the teaching and learning of mathematics. Journal of Research in Mathematics Education. Monograph 4 (pp. 7-18). Reston, VA: National Council of Teachers of Mathematics.

Novak, J., & Gowin , D. B.. (1984). Learning how to learn. New York: Cambridge University Press.

Nussbaum, J. (1982). Alternative frameworks, conceptual conflict and accommodation: Toward a principled teaching strategy. Instructional Science, 11, 183-200.

Owen, J., & Johnson, M., (1987). Mathematics Curriculum and Teaching Program (MCTP). Canberra, Australia: Curriculum Development Centre. (ERIC Document Reproduction Service No. ED 287 722)

Patton, M. Q. (1990). Qualitative evaluation and research methods. Newbury Park, CA: Sage Publications.

Peterson, P. L. (1988). Teaching for higher-order thinking in mathematics: The challenge for the next decade. In D. A. Grouws (Ed.), Perspectives on research on effective mathematics teaching, vol. 1 (pp. 2-26). Reston, VA: National Council of Teachers of Mathematics.

Piaget, J. (1970). Genetic epistemology. New York: Columbia University Press.

Pimm, D. (1987). Speaking mathematically: Communication in mathematics classrooms. London: Routledge & Kegan Ltd.

Plato. (1986). The republic. (B. Jowett, Trans.). Buffalo: Prometheus Books. (Original work published 360 B. C. circa)

Reimers, F. (1991, October). Time and opportunity to learn in Pakistan's schools. Paper presented at the Northeast Universities Development Consortium Conference, Cambridge, MA. (ERIC Document Reproduction Service No. ED 350 202)

Renninger, K. A., & Winegar, L. T. (1985, August). Organization of teacher-student interaction: Differential constraining progressive empowerment. Paper presented at the Annual convention of the American Psychological Association, Los Angeles, CA. (ERIC Document Reproduction Service No. ED 270 659)

Rogers, C. R. (1969). Freedom to learn. Columbus, OH: Charles E. Merrill Publishing Company.

Rutherford, W. (1986, April). Teachers' contributions to school improvement: Reflections on fifteen years of research. Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, CA. (ERIC Document Reproduction Service No. ED 217 462)

Samuelowicz, K., & Bain, J. D. (1992). Conceptions of teaching held by academic teachers. Higher Education, 24(1), 93-111.

Schifter, D. & Fosnot, C. T. (1993). Reconstructing mathematics education: Stories of teachers meeting the challenge of reform. New York: Teachers College Press.

Schofield, J. W., & Anderson, K. M. (1984, January). Integrating quantitative components into qualitative studies: Problems and possibilities for research on intergroup relations in educational settings. Paper presented at a meeting of the Society for Research on Child Development Study Group on Ethnic Socialization, Los Angeles, CA. (ERIC Document Reproduction Service No. ED 248 250)

Schram, P., Wilcox, S., Lanier, P., & Lappon, G. (1988, April). Changing mathematical conceptions of preservice teachers: A content and pedagogical intervention: Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA. (ERIC Document Reproduction Service No. ED 302 549)

Seidman, I. E. (1991). Interviewing as Qualitative Research. New York: Teachers College Press.

Shavelson, (1983). Review of research on teachers' pedagogical judgments, plans, and decisions. Elementary School Journal. 83(4), 392-413.

Sikka, A., Tedder, N. E., & Ewing, S. M. (1991, November). Combining qualitative and quantitative data: An example. Paper presented at the Annual Meeting of the Mid-South Educational Research Association, Lexington, KY. (ERIC Document Reproduction Service No. ED 344 908)

Simon, M. A., & Schifter, D. (1991). Towards a constructivist perspective: An intervention study of mathematics teacher development. Educational Studies in Mathematics. 22(4), 309-31.

Skemp, R. R. (1987). Psychology of learning mathematics. Hillsdale, NJ: Lawrence Erlbaum Associates.

Sparks, G. M. (1984). Inservice education: The process of teacher change. Paper presented at the Annual Meeting of the American Educational Research Association. (ERIC Document Reproduction Service No. ED 244 930)

Steffe & Killion (1986, July). Mathematics teaching: A specification in a constructionist frame of reference. In L. Burton & C. Hoyles (Eds.), Proceedings of the Tenth International Conference, Psychology of Mathematics Education, (pp. 207-216). London: University of London Institute of Education.

Stover. L. T. (1990). Modeling a student-centered approach in the secondary teacher education program. Action in Teacher Education, 12(1), 35-42.

Systemic Initiative for Montana Mathematics and Science. (1992a). Philosophy statement. Unpublished manuscript, Montana Council of Teachers of Mathematics.

_____ (1992b). Outcomes for Summer Institute. Unpublished manuscript, Montana Council of Teachers of Mathematics.

_____ (1993). The SIMMS project philosophy statements: Monograph 1. Missoula, MT: Montana Council of Teachers of Mathematics.

Troisi, N. F. (1983). Effective teaching and student achievement. Reston, VA: National Association of Secondary School Principals. (ERIC Document Reproduction Service No. ED 231 067)

von Glasersfeld, E. (1990). An exposition of constructivism: Why some like it radical. In R. B. Davis, C. A. Maher & N. Noddiz (Eds.), Constructivist views on the teaching and learning of mathematics. Journal of Research in Mathematics Education, Monograph 4 (pp. 19-30), Reston, VA: National Council of Teachers of Mathematics.

Wittrock, M. C. (Ed.). (1986). Handbook of research on teaching, (3rd ed.) New York: Macmillan Publishing Company.

Ysseldyke, J. E., Thurlow, M., & Christenson, S. (1987). Teacher effectiveness and teacher decision making: Implications for effective instruction of handicapped student Instructional Alternatives Project: Monograph 5. Minneapolis, MN: Minnesota University. (ERIC Document Reproduction Service No. ED 293 268)

APPENDICES

APPENDIX A

INTERVIEW EXAMPLES

Guidelines for Interview Questions

Introductory statement: The questions I will be asking do not have any right or wrong answers. I am interested in your feedback and insights on the various topics. I would like to audiotape the interview so I don't have to take so many written notes and can concentrate on understanding your ideas. I am the only one who will listen to the tape and all identification will be removed from any feedback shared with SIMMS personnel.

I would like this first interview to focus on the summer institute, but if other ideas come to mind that you feel are important please feel free to mention them. You are the person in the classroom, I am here to learn from you.

[Items in brackets were follow-up suggestions or extension questions in the event the person being interviewed was not sure how to respond.]

First Interview: Summer Institute

1. What aspects of your summer institute in Bozeman were the most helpful in being prepared to teach the SIMMS modules? Why?

   What impact did it have on your classroom?

[Items from Goals and Outcome for 1992 Summer Teacher/Leader Institute: personal journal, cooperative learning, alternative forms of assessment, gender and/or minority equity issues, writing in mathematics classroom, techniques of problem solving which empower students and teacher, technology in the classroom, telecommunications, structure, rationale, content and pedagogy of SIMMS materials.]

2. What aspects of the summer institute were the least helpful? Why?

3. Did you feel prepared to teach the SIMMS modules? If not, for which aspects of teaching SIMMS modules were you unprepared? Examples?

4. Did you change any of your ideas about teaching as a result of this summer's institute? If yes, please describe these changes?

Second Interview: Teaching Modules

1. Would you compare the mathematics your SIMMS students are learning with the mathematics the ninth grade non-SIMMS students in your school are learning?

   [Differences? Similarities? What topics are SIMMS students missing out on? What are SIMMS students getting that non-SIMMS students are not?]

2. Do you have any suggestions for changes in any aspect of the SIMMS program that would help you to be more effective in your classroom?

   [Inservice, format of modules, classroom environment]

3. Are there characteristics of your school environment or students that hinder or help in teaching SIMMS material?

4. Would you compare teaching your SIMMS and non-SIMMS classes?

   [Require more preparation? Require more stamina in classroom? Require expertise beyond your preparation?]

Third Interview: Non-SIMMS classrooms

1. Do you see any differences between your SIMMS and non-SIMMS classroom environments?

   [Student actions? Teacher actions? Classroom atmosphere?]

2. Do you feel you act differently in your SIMMS and non-SIMMS classes? If yes, what makes you act differently?

3. Do you use cooperative learning groups in your non-SIMMS classrooms? If so, please explain the cooperative learning techniques you used. How often did you use cooperative learning groups in non-SIMMS classes as compared to SIMMS classroom?

4. What is the role of a facilitator? What percentage of a class period do you spend being a facilitator?

5. Have your ideas about SIMMS changed since September?

Excerpts from Third Interview with Adam

Excerpt 1

INTERVIEWER: Do you feel as though you act differently in your SIMMS class than in your non-SIMMS classes?

TEACHER: Oh, at the beginning of the year, I definitely did. There's no doubt. Any time I'm in a class that I teach the first time, you're unsure of yourself, you don't exactly know where things are going. You don't have a clue where it's going or what's happening. I would doubt that anybody could be the same in their SIMMS classes. All the other classes I teach now, I've taught before. So, you know exactly what's been covered, what's going to be covered, where the students have trouble, where they don't have trouble. In the SIMMS room you always have to be anticipating what's happening. You always have to be very observant of what's happening. I'm trying to get to the same place in SIMMS that I am in in my other classes as far as, "Okay now, this activity they kind of have problems with - maybe give them a little more direction. This one, back way off. Let them go on their own because they really came up with some neat stuff on their own. And, of course, next year with the materials, it's going to be new again. The activities are not going to look the same again and so I think that you're going to go through that again, but then the following year, I think people will settle in more.

INTERVIEWER: So you're saying that the difference is your comfort level with it?

TEACHER: I think that's part of it. Yeah. Yeah, I do.

INTERVIEWER: Then how does this affect how you interact with your students?

TEACHER: I don't think it changes that much as far as, I'm always real open to my kids, and that type of thing. I think that the fact

that I'm not as close with my SIMMS students is more a time element than the comfort level thing. There isn't the time to sit, we're just jamming through these things, it's just crazy. There just isn't time to sit and visit with the kids. There isn't time to get to know the kids other than if I have them after school. Whereas in my regular classes there may be a day when there's not very many questions over homework, and we go through the lecture. It goes quick and smooth and they start working at their desks and I just go around and I just talk with them or maybe at the beginning of the hour we take five or ten minutes and talk about something. But in SIMMS you can't afford that. You can't afford to lose that time. As far as my comfort with the material, that does not really affect how I feel about my kids. Kids are kids and it doesn't have anything to do with the class they're taking.

Excerpt Two

INTERVIEWER: Why don't you describe what your group activities are like in your non-SIMMS classes.

TEACHER: The majority of the group work that I do would be in Geometry, which I'm not teaching this year. And I do a lot of group work in Geometry, and I would say that my group work in Geometry most resembles what I'm doing in my SIMM room. In Algebra II-Trig, we work some in groups. But mainly it's just, I let them pair off, usually. It's just working on a homework assignment. Some of the roles that I do stick to in Algebra II that I do in the SIMM room is that you've got to exhaust all of the resources in your group before you come up and ask me a question. You need to depend on each other. You need to work it out. You need to seek the help of another group, that type of thing. Trying to get some work back and forth between the groups. One thing, too, I find out is with juniors and seniors, they kind of do that a lot more naturally than ninth graders. They really hammer on it in their group and then if they can't get it they usually ask the kid next to them. "Did you guys get this?" And they do so much of that real naturally. But in there, I didn't ever set anything up like in SIMMS where we actually physically put them in the groups. These are the groups you'll work in for the entire module. I never do that in an Algebra II-Trig

class. I just let them group as they want to. I also in my Algebra II-Trig don't make kids get in groups if they don't want to, all the time, sometimes I do. Sometimes I say, "I want four in each group, no more than four." Other times I say, "Just get in a group you're comfortable with."

Excerpt Three

INTERVIEWER: Would you give me your definition of a facilitator of learning?

TEACHER: I guess probably a lot of my definition stems from my "Care" training here because we facilitate groups and things like that. I think a facilitator is-- their role is to get the discussion started ,but then once it's started to stand back and allow the discussion to go on between the participants. They are not necessarily a part of that at all times. You are to make sure that the discussion stays focused, that people aren't getting off the track and that type of thing. I guess I have a tendency to lead more in my SIMMS room than in a "Care" group that I'm facilitating. In a "Care" group the kids are very comfortable with the issues because the issues are theirs and they just go with it, whether it be a divorce group or growth group or whatever type of group. The kids, they have a tendency to kind of get off on telling stories and stuff and not working on their issues and not the purpose of the group which is to work on their own issues and do something about them. In SIMMS, the discussion is not always on something that they really know about, care about, or understand and so as a facilitator I have to be more active in that because there's just a lot of things they don't know about. I'm amazed when we do these. I'm finding that a lot of the modules are adult issues. That as we've grown and developed through our lives, we've picked up a lot of attitudes and feelings about these things, but these kids on the ninth grade level haven't. Like population, we watched. We've lived through baby booms and watched population and stuff. These kids haven't really paid that much attention to population. Some of them have some issues there, but they're their parents issues, mainly. They're not theirs. So there, sometimes they need, some ideas of what to go with and what to talk about and those type of

things. They're not necessarily things they would bring up on their own. Once you bring some things up though, it seems like then they can carry the discussion again for a while.

INTERVIEWER: How much of your class time in your SIMMS and non-SIMMS do you think you spend being a facilitator?

TEACHER: In non-SIMMS?

INTERVIEWER: In SIMMS or in non-SIMMS, is it different in the two?

TEACHER: Oh, huge difference. I would say in SIMMS, I'm a facilitator a lot of the time, because when the kids are working in groups, all you're doing is answering their questions so they can keep going on. Somebody says, "How do I do this on the computer?" You show them and then they're off and going. In fact, in SIMMS, a lot of times I don't even feel like I'm facilitating it because I've got eight different groups and I can't facilitate eight groups at one time. I can facilitate one group at one time. So, I've got seven groups that are on their own. And I've got one. And then I'm rotating that around.

INTERVIEWER: Does that -- telling them how to do something on the computer -- fit into your definition of being a facilitator?

TEACHER: If that helps the discussion to continue on, yes. If that's what stopped the discussion. So, they were analyzing some data and they needed something, and they couldn't get it and then I helped them to do that and the discussion continued. Yeah, I consider that facilitating.

INTERVIEWER: And would you say that maybe 60% of the time in your SIMMS class you would be a facilitator, or would it be more than that?

TEACHER: Yeah, at least that. It could be 75% at the most.

INTERVIEWER: What about your non-SIMMS class?

TEACHER: You know, I'd like to- Boy, that's a really hard question. I try in my regular classes to get the kids to throw out their ideas and stuff. But then I have a tendency when things get off track to be more directive and lead them to where I want them to be. Yeah, I think people would have different opinions as to whether I'm really facilitating in there or whether I'm just teaching directly. It's definitely under 50%, there's no doubt about that.

APPENDIX B

INTERACTION CODES

Interaction Code Explanation

2: Assists students in organizing cooperative learning groups: Teacher assigns student to particular groups and assists students in working together effectively.

3: Has students do class presentations: students get up in front of class and give formal presentations based on their group work.

6: Demonstrates use of appropriate technology to help solve problems: Teacher demonstrates how the use of a computer or calculator assists in the solving a particular problem situation.

7: Encourages students to use appropriate technology to help solve problems: Teacher suggests the students use the computer or calculator to assist in solving a particular problem.

8: Requires students to express mathematical ideas in written and oral form: Teacher asks students to present problem solutions to class or write out explanations of solutions. This code was not used for responses to short answer questions. It was used when students were giving explanations of work or when the teacher was assisting students in composing written explanations.

10: Encourages discussion among students about problems and possible solutions: Teacher did not immediately pass judgment on suitability of problem solution, but allows students to consider possible alternatives.

11: Attempts to understand student's rationale for his/her work: Teacher tried to truly tried to understand a student's approach to a problem instead of simply having the student explain their work so the teacher could determine if the correct algorithm had been used.

12: Brings up evidence that conflicts with a student's interpretation so student can reexamine his/her thinking: teacher asks students to consider how their idea would apply in a different situation and allows student to consider problem.

13: Asks process-oriented questions: Teacher's questions focus on the way a problem is solved more than on the solution. The code was also used when a teacher asked which algorithm was appropriate in a given situation.

14: Asks open-ended questions: Teacher's questions are open to interpretation and/or do not have an expected response.

15: Moderates discussions on student generated ideas: Teacher invites other students to comment on ideas which were generated by other students.

16: Helps students to rely on themselves to determine whether something is mathematically correct: Teacher assists students in determining how they can judge the correctness of their solution. This code was not used if the teacher gave specific directions on how to find a solution.

18: Asks judgment questions: Teacher's question requires students to analysis situation and apply concepts discussed or draw on previous knowledge.

sr: Has students report on group work: students report on results of group work. No analysis of work is required on their part. This code was not used for formal presentations.

di: Uses direct instruction: situations in which the teacher assumes authority by either providing information about the topic, demonstrating an algorithm or telling students their answers were correct.

ra: Reads answers to students' assignment: Teacher or student reads from answer key.

sa: Asks short answer questions: Teacher asks questions which have an expected answer and teacher passes judgment on correctness of that answer.

ta: Helps with the mechanics of the calculator or computer: Teacher helps students operate the given device. This code was used only when the teacher was helping students with actions such as entering a formula, clearing the screen, getting a graph printed, or finding a lost file.

td: Gives directions: Teacher gives directions such as how to proceed with the mechanics of the assignment, how to turn in papers, or what grading procedure would be used.

APPENDIX C

EXAMPLES OF INTERACTION DOCUMENTATION

Example of Field Notes

David SIMMS Class [Date]

20 students present

8:16 Teacher gets manipulatives for group work. Bell.

8:17 Announcements over the PA system. Teacher quiets class. Students organize manipulatives. Teacher takes roll and gets lunch count.

8:19 Teacher asks student to open books. Class is noisy.
8:20 Outside interruption.

Students are working on experiment. Some keeping track of data on spreadsheet, some by hand.

Students often call out for teacher. Teacher ignores them if busy with another group. Students then wait patiently or try to solve problem themselves. Teacher goes to that group later.

Teacher discusses, in several groups, problems students are having with experiment and asks for possible solutions.

8:40 Teacher sits with group and suggests entries for spreadsheet.

8:44 Two groups are off task.

One student, who had not been doing anything in previous visits, tries to get his group back on task.

Groups get back on task as teacher comes to check on what they are doing.

8:52 Teacher reminds groups that are finished with experiment what else they need to work on.

Two groups ask to finish Monday as they need more M&M's and skittles. Only two groups still on task. Others into social conversations. Another group is only half on task.

9:03 Students turn off computers. Most of the conversations are social. One group goes to stand by door.

9:06 Bell Teacher reminds students to cleanup, turn off and cover computers. One group still working with manipulatives.

Excerpt from Transcript 36 - David's SIMMS Class

[Numbers in parentheses refer to tape recorder counter.]

T: Well, what happened, then when we were doing coyotes and rabbits? What happened when all the M & M's -- what's that like when all the M & M's are gone.
S2: All the rabbits are gone.
S4: No, the rabbits keep multiplying and multiplying.
T: OK, there were -
S2: Nothing to get rid of them.
T: Yeah, all of the -
S2: Yeah but how come -
T: Why, why did the rabbits keep on multiplying, then?
S3: Because there is nothing to kill them
T: Nothing to eat them, right? Why did the coyotes die in the first place?
S3: (recording unclear)
T: But in our box here, are there any hunters?
S3: No.
S4: Poisons
T: Poisons. Why did they die though?
S: They weren't close enough to a skeeter.
T: OK, they weren't close enough to a skeeter. So what's that represent in the --
S: Oh, they starved.
T: They starved, didn't they. Nothing for them to eat so they starved. That would be like taking the whole state of Montana and putting ten rabbits out there with twenty coyotes and that's the only thing they could eat. OK, what could be done to solve this thing. Sarah had an idea, there.
S: (recording unclear)
T: Either more or what's another option? What could we do? Could we try it again with some changes? OK, they [another group] ran into the same problem. What would you like to try then?
S3: We could start over and every generation place one in there.

T: OK, you could transplant some in there. What's some other options? Why did the M&M's --
S4: They were so big, and they rolled away.
T: They rolled away. OK, what's this like in a -- can we relate these two things to something in our life or our society or our world?
S: (pause) I have no idea.
S1: These are rabbits.
T: Those are rabbits.
S: And these are-- people.
T: People?
S1: Wolves.
T: Wolves, wolves. OK, so, why, why did all of these, why did all the wolves die off in this population, in here.
S1: Not enough food.
T: There wasn't enough food. They starved, didn't they. So what could we do to help them out?
S: Add more rabbits
T: Add more rabbits. Make more food. OK, what else could we do?
S1: We could put them in captive, captivity and let them multiply -
T: Oh, let them multiply in captivity--
S1: -and then put them back in.
T: -and feed them and then introduce them again. OK, the other thing is, where, this might be--
S: Too big.
T: Too big, wouldn't it.
S: So we could confine it to a small area.
T: Yeah, what we could do is maybe is put a block in there something or a ruler or something in there, is something you could do.
S: Make it smaller so the wolves don't have to run so far.
T: Oh, OK, so they wouldn't have to run so far to get food, good. I see what, I don't if we can--
(121)
(123)
T: Would a ruler fit in there or a (recording unclear)? Or what we could do is get a--what's another option?
S1: Switch the box.

T: Different size box or maybe--
Ss: (recording unclear)
T: Yeah, or maybe we could use a piece of cardboard and tape in there some. Do you want to do that?
Ss: Yeah, sure.
(125)
(127)
S2: Use a (recording unclear) box to shake in.
T: OK. Did you start over? Is that what you guys did?
S3: That's what we did?
T: Did they die yet?
Ss: No.
S: We haven't got that far yet.
T: Haven't got that far yet. What did you do?
S4: We started over from the--.
S5: We doubled, we doubled (recording unclear)
T: Increased the beginning population.

APPENDIX D

SAMPLES OF DATABASE SUMMARIES

Explanation of Summaries

Percentages were based on the number of characters in the coded interaction. An average number of characters per unit of the tape recorder counter were calculated for each teacher so non-verbal interactions, *teacher monitoring (tm)*, could be estimated from length of interval.

Under the Codes heading, the number or letters before the hyphen is the interaction code. A description of the codes may be found in Appendix B. 'Sq' denotes interactions initiated by a student question or comment. The number after the hyphen is a group code, 0 for whole class and 1 for small group. Whole class instruction was those times when all of the students were supposed to be focused on the same interaction.

Table 1. Interaction Code Summary for Transcript 36.

Transcript total length (in characters):19,087

Length for whole class situations: 484
Percentage: 2.5%

Codes	Length	Percent
10 - 1	4,151	21.7
12 - 1	233	1.2
13 - 1	1,305	6.8
15 - 1	1,542	8.1
18 - 1	1,181	6.2
2 - 1	150	0.8
di - 1	1,107	5.8
sa - 1	261	1.4
sq,10 - 1	893	4.7
sq,13 - 1	187	1.0
sq,di - 1	3,43	18.0
sq,ta - 1	249	1.3
sq,td - 1	484	2.5
sr - 1	135	0.7
ta - 1	205	1.1
td - 0	484	2.5
td - 1	869	4.6
tm - 1	2,218	11.6

Table 2. Interaction Code Summary for All Sessions of David's SIMMS Class..

Transcripts total length (in characters):101,945

Length for whole class situations: 39,001
Percentage: 38.3%

Codes	Length	Percent	Codes	Length	Percent
10 - 0	3,294	3.2	sq,11 - 1	477	0.5
10 - 1	7,090	7.0	sq,13 - 1	187	0.2
12 - 0	783	0.8	sq,15 - 1	421	0.4
12 - 1	233	0.2	sq,16 - 1	107	0.1
13 - 0	2,003	2.0	sq,di - 0	885	0.9
13 - 1	2,186	2.1	sq,di - 1	11,570	11.3
15 - 0	3,164	3.1	sq,sa - 1	650	0.6
15 - 1	3,180	3.1	sq,ta - 1	6,829	6.7
16 - 0	371	0.4	sq,td - 0	567	0.6
17 - 0	290	0.3	sq,td - 1	3,170	3.1
18 - 0	706	0.7	sr - 0	1,206	1.2
18 - 1	1,181	1.2	sr - 1	199	0.2
2 - 0	493	0.5	ta - 0	53	0.1
2 - 1	1,694	1.7	ta - 1	6,572	6.4
3 - 0	5,700	5.6	td - 0	5,056	5.0
6 - 0	662	0.6	td - 1	3,306	3.2
7 - 0	395	0.4	tm - 0	146	0.1
7 - 1	886	0.9	tm - 1	5865	5.8
di - 0	8,808	8.6			
sa - 0	4,419	4.3	Total Interactions		
sa - 1	750	0.7	Student-centered - 25%		
sa,ta - 1	167	0.2	Teacher-centered - 37%		
sq,10 - 1	1,624	1.6			

Table 3. Interaction Code Summary for Composite SIMMS Class.

Transcripts total length: 463, 684

Length for whole class situations: 259,434
Percentage: 56.0%

Codes	Length	Percent	Codes	Length	Percent
10 - 0	9,359	2.0	sa,ta - 1	167	0.0
10 - 1	14,158	3.1	sq,10 - 0	1,451	0.3
11 - 0	913	0.2	sq,10 - 1	10,095	2.2
11 - 1	674	0.1	sq,11 - 1	477	0.1
12 - 0	750	0.2	sq,12 - 1	311	0.1
12 - 1	551	0.1	sq,13 - 1	496	0.1
13 - 0	7,745	1.7	sq,15 - 0	440	0.1
13 - 1	4,264	0.9	sq,di - 0	5,815	1.3
14 - 0	912	0.2	sq,di - 1	31,204	6.7
15 - 0	10,391	2.2	sq,sa - 1	1,302	0.3
15 - 1	4,392	0.9	sq,ta - 0	126	0.0
18 - 0	7,276	1.6	sq,ta - 1	14,981	3.2
18 - 1	463	0.1	sq,td	293	0.1
2 - 0	2,927	0.6	sq,td - 1	18,118	3.9
2 - 1	2,629	0.6	sr - 0	6,166	1.3
3 - 0	20,500	4.4	sr - 1	1,045	0.2
6 - 0	3,161	0.7	ta	296	0.1
6 - 1	245	0.1	ta - 0	1,805	0.4
7 - 0	2,771	0.6	ta - 1	12,620	2.7
7 - 1	3,042	0.7	td - 0	60,331	13.0
8 - 0	4,816	1.0	td - 1	14,659	3.2
8 - 1	421	0.1	tm - 0	2,642	0.6
di - 0	72,276	15.6	tm - 1	47,676	10.3
di - 1	18,271	3.9	---	---	---
sa - 0	29,158	6.3	Total Interactions		
sa - 1	1,400	0.3	Student-centered - 18%		
			Teacher-centered - 56%		

Table 4. Interaction Code Summary for Composite Non-SIMMS Class.

Total length (in characters): 413,295

Total length of whole class situations: 261,702
Percentage: 63.3%

Codes	Length	Percent	Codes	Length	Percent
10 - 0	1,195	0.3	sq,10 - 1	2,181	0.5
10 - 1	5,524	1.3	sq,11 - 1	566	0.1
11 -	1,303	0.3	sq,13 - 0	1,895	0.5
12 - 1	1,465	0.4	sq,13 - 1	494	0.1
13 - 0	12,878	3.1	sq,7 - 1	218	0.1
13 - 1	942	0.2	sq,di - 0	16,068	3.9
14 - 0	162	0.0	sq,di - 1	64,568	15.6
17 - 0	205	0.0	sq,sa - 0	3,904	0.9
18 - 0	384	0.1	sq,sa - 1	7,410	1.8
2 - 0	792	0.2	sq,ta - 1	3,306	0.8
2 - 1	67	0.0	sq,td - 0	2,487	0.6
3 - 0	670	0.2	sq,td - 1	5,702	1.4
6 - 0	123	0.0	ta - 1	1.230	0.3
6 - 1	496	0.1	td - 0	44,988	10.9
7 - 0	729	0.2	td - 1	1,997	0.5
8 - 0	1,167	0.3	tm - 0	4,007	1.0
di - 0	99,792	24.1	tm - 1	10,101	2.4
di - 1	27,684	6.7	----------		
ra - 0	14,382	3.5	Total Interactions		
sa - 0	55,241	13.4	Student-centered - 7%		
sa - 1	16,105	3.9	Teacher-centered - 84%		
sq,10 - 0	633	0.1			

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