



A study of possible factors that influence the construction of teacher-made problems that assess higher-order thinking skills  
by David Lynn Harpster

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Education in Secondary Curriculum and Instruction  
Montana State University  
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**Abstract:**

The problem addressed by this study was to analyze statistically the possible influence of several profession-related factors on the levels of questions Montana public high school mathematics teachers would use in their classrooms to assess higher-order thinking skills.

Questionnaires were sent to 220 public high school mathematics teachers in the state of Montana during the winter of 1998. Chi-square tests of independence were used to determine if there was a relationship between the categorization of the teachers' written examples of a question that tests for higher-order thinking skills and o the amount of SIMMS professional development that the teachers had received; o the use of the SIMMS IM curriculum in the teachers' classrooms; o the number of credit hours that the teachers had accumulated from college classes in assessment or evaluation; o the highest academic degree obtained by the teachers; and o the educational objective from Bloom's taxonomy that the teachers ranked most important for their classroom.

ANOVA tests were used to determine if there was a significant difference between o the mean number of hours of professional development for teachers who wrote Level I, Level II, Level III, or Level IV questions as examples of questions that test for higher-order thinking skills; o the mean number of years teaching mathematics for teachers who wrote Level I, Level II, Level III, or Level IV questions as examples of questions that test for higher-order thinking skills.

To help interpret the results of this study, telephone interviews were conducted with ten of the teachers who had returned questionnaires.

No significant relationship or difference was found for any of the factors stated above. Almost 60% of the teachers participating in this study wrote a question that assessed lower-order thinking skills when asked to write a question that assessed higher-order thinking skills.

Professional development, college measurement courses, and continuing education do not seem to impact teachers' assessment of higher-order thinking skills; furthermore, we cannot assume that teaching experience alone, without proper training and classroom support, will improve this situation.

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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## ABSTRACT

The problem addressed by this study was to analyze statistically the possible influence of several profession-related factors on the levels of questions Montana public high school mathematics teachers would use in their classrooms to assess higher-order thinking skills.

Questionnaires were sent to 220 public high school mathematics teachers in the state of Montana during the winter of 1998. Chi-square tests of independence were used to determine if there was a relationship between the categorization of the teachers' written examples of a question that tests for higher-order thinking skills and

- the amount of SIMMS professional development that the teachers had received;
- the use of the SIMMS IM curriculum in the teachers' classrooms;
- the number of credit hours that the teachers had accumulated from college classes in assessment or evaluation;
- the highest academic degree obtained by the teachers; and
- the educational objective from Bloom's taxonomy that the teachers ranked most important for their classroom.

ANOVA tests were used to determine if there was a significant difference between

- the mean number of hours of professional development for teachers who wrote Level I, Level II, Level III, or Level IV questions as examples of questions that test for higher-order thinking skills;
- the mean number of years teaching mathematics for teachers who wrote Level I, Level II, Level III, or Level IV questions as examples of questions that test for higher-order thinking skills.

To help interpret the results of this study, telephone interviews were conducted with ten of the teachers who had returned questionnaires.

No significant relationship or difference was found for any of the factors stated above. Almost 60% of the teachers participating in this study wrote a question that assessed lower-order thinking skills when asked to write a question that assessed higher-order thinking skills.

Professional development, college measurement courses, and continuing education do not seem to impact teachers' assessment of higher-order thinking skills; furthermore, we cannot assume that teaching experience alone, without proper training and classroom support, will improve this situation.

## CHAPTER 1

## PROBLEM STATEMENT AND REVIEW OF LITERATURE

IntroductionThe Impact of Assessment

Assessment substantially impacts the public school classroom. Crooks (1988), in his review of the literature on classroom assessment, found that assessment affects students in several ways:

For instance, it [assessment] guides their judgment of what is important to learn, affects their motivation and self-perceptions of competence; structures their approaches to and timing of personal study (e.g., spaced practice), consolidates learning, and affects the development of enduring learning strategies and skills. It appears to be one of the most potent forces influencing education. (p. 467)

That assessment is such a potent force is not unexpected considering that, on average, formal written tests alone occupy from five to fifteen percent of a student's time (Crooks, 1988). The lower figure is more typical of elementary school students whereas the higher figure is more typical of high school students. In addition, teachers may spend as much as 20 to 30% of their professional time directly involved in assessment-related activities. (Stiggins, 1988).

### Higher-Order Thinking Skills

Assuming that assessment substantially impacts the public school classroom, then what thinking skills should be emphasized through assessment? The demands of business and industry suggest that higher-order thinking skills should be emphasized in education. For example, Cross (1985) believes that both small businesses and industry will need workers who can synthesis and utilize information; higher-order thinking skills according to Bloom's taxonomy. Likewise, Daggett (1996) recommends an emphasis on the transfer of knowledge to unpredictable situations. He believes that this is an area where American students lag behind both European and Asian students, with possibly profound economic and social consequences in the future.

Research on the levels (according to Bloom's taxonomy) at which teachers assess their students indicates that, generally, they assess lower-order thinking skills. For instance, Fleming and Chambers (1983) in their research of the Cleveland school district concluded that "... teacher-made tests do not require students to display higher order abilities". (p. 30) Nine years later, in his study of Georgia secondary mathematics teachers, Cooney (1992) found that "... many teachers equate a deeper understanding of mathematics with the ability to perform more difficult computations or to solve one step problems". (p. 18)

### The SIMMS Project

In 1991, the state of Montana received funding from the National Science Foundation (NSF) for the Systemic Initiative for Montana Mathematics and Science (SIMMS) Project. The SIMMS Project had nine objectives:

1. Promote integration in science and mathematics education.
2. Redesign the 9-12 mathematics curriculum using an integrated interdisciplinary approach for all students.
3. *Develop and publish curriculum and assessment materials for grades 9-16* [italics added].
4. Incorporate the use of technology in all facets and at all levels of mathematics education.
5. Develop an action plan to increase the participation of females and Native Americans in mathematics and science.
6. Establish new certification standards and recertification standards for teachers.
7. Redesign teacher preparation programs using an integrated interdisciplinary approach.
8. *Develop an extensive inservice [sic] program in mathematics grades 9-16 to prepare teachers for integrated programs* [italics added].
9. Develop the support structure for legislative action, public information and general education of the populace. (SIMMS Project, Summer, 1997, pp. 2-7)

There has to date, been no research on the impact of SIMMS professional development on the assessment practices of SIMMS certified teachers.

#### Statement of the Problem

The problem addressed by this study was to statistically analyze the relationship between specific factors (listed below) and the levels of questions Montana public high school mathematics teachers would use in their classroom to assess higher-order thinking skills. This study was conducted to answer the following questions. Using Cooney's taxonomy for categorizing mathematical test questions,

1. What levels of questions do Montana public high school mathematics teachers write to assess the higher-order thinking skills of their students?
2. Is there a significant difference in the amount of professional development that Montana public high school mathematics teachers have received based upon

the categorization of their written examples of questions that they would use in their classroom to test for higher-order thinking skills?

3. Is there a significant difference in the number of years teaching mathematics for Montana public high school mathematics teachers based upon the categorization of their written examples of questions that they would use in their classroom to test for higher-order thinking skills?
4. Is there a pattern or relationship between the categorization of Montana public high school mathematics teachers' written examples of questions they would use in their classroom to test for higher-order thinking skills and
  - the amount of SIMMS professional development that they have received;
  - their use or non-use of the SIMMS IM curriculum;
  - the number of credit hours that they have accumulated from college classes in assessment or evaluation;
  - their highest academic degree;
  - the order in which they rank the importance of the educational objects from Bloom's taxonomy.

Furthermore, what rationale do teachers give for determining if a question assesses higher-order thinking skills?

### The Importance of the Study

There is ample evidence from the literature suggesting that assessment, through teacher-generated tests, has an impact upon what and how students learn. In addition, studies of teacher-made tests indicate that teachers often assess predominantly lower-order thinking skills, relative to Bloom's taxonomy. What the literature does not tell us is the cognitive levels of the questions that teachers would use in their classroom to test for higher-order thinking skills and what factors may influence this. The study by Cooney (1992) was the first step in providing answers to these questions, with respect to secondary mathematics teachers. However, in the absence of further research to support or confirm his conclusions, we cannot generalize his results across the whole population of public high school mathematics teachers in this country.

The importance of this study is that it informs mathematics educators of the cognitive levels, according to Cooney's taxonomy, of questions that a specific population of teachers (Montana public high school mathematics teachers) would use in their classroom to assess higher-order thinking skills. It also sheds some light on the impact that SIMMS professional development, the SIMMS IM curriculum, and other factors have had upon the cognitive levels of questions that teachers would use in their classroom to assess higher order thinking skills.

Before we as mathematics educators suggest methods to remedy the problem of public high school mathematics teachers assessing, predominantly, lower-order thinking skills, we must first know what levels of questions teachers believe assess higher-order thinking skills and what factors may influence those beliefs. If we do not determine the

specific factors that influence teacher beliefs about the assessment of higher-order thinking skills, then we may be throwing solutions at problems that we do not adequately understand.

### Definition of Terms

For the purpose of this study, the researcher will use the following definitions:

Assessment: The comprehensive accounting of an individual's or group's functioning within a specific subject area or application of that subject area. (Adapted from Webb, 1992, pp. 662-663)

Cooney's Taxonomy: A modification of Bloom's taxonomy used to classify questions from tests and quizzes in mathematics. Cooney's taxonomy consists of the following levels:

Level 1 questions are those that require recognition on the part of the student or a simple computation. This category is synonymous with *Knowledge* in Bloom's taxonomy.

Level 2 questions require a student to make some decision, but once made the solution process is straightforward (e.g., a simple one-step problem). This category is synonymous with *Comprehension* in Bloom's taxonomy.

Level 3 questions are application questions or multiple-step problems in which a student must make several decisions about the solution process or what operations to use. This category is synonymous with *Application* in Bloom's taxonomy.

Level 4 questions are non-routine or open-ended problems. This category is

synonymous with the combination of *Analysis*, *Synthesis*, and *Evaluation* from Bloom's taxonomy.

Evaluation: Assigning value to the results of an assessment.

Higher-Order Thinking Skills: These would include the following skills from Bloom's taxonomy: *Application*, *Analysis*, *Synthesis*, and *Evaluation* (Levels 3, 4, 5, and 6, respectively).

High School: Grades nine through twelve in the public schools.

Lower-Order Thinking Skills: These would include the following skills from Bloom's taxonomy: *Knowledge* and *Comprehension* (Levels 1 and 2, respectively).

Non-SIMMS IM: A Montana teacher who has received less than three hours of SIMMS professional development.

Open-ended Question: Using Frederiksen's (1994, p.538) definition, a question is open-ended if it (a) is non-algorithmic; (b) is complex; (c) may yield more than one solution, each of which has different benefits and/or disadvantages; (d) may require nuanced judgments -- sensitivity to subtle aspects of a problem situation; (e) may involve the application of multiple and sometimes conflicting criteria; (f) may involve uncertainty because all of the facts are not known; (g) may involve self-regulation of the thinking process (metacognition); (h) may require one to find structure in apparent disorder; and (i) requires effort because of the complexity of problems.

SIMMS IM certified: A Montana teacher who has received a minimum of two weeks (60 or more hours) of SIMMS professional development.

SIMMS IM trained: A Montana teacher who has received from one to two weeks (30 hours to 59 hours) of SIMMS professional development.

SIMMS IM introduced: A Montana teacher who has received from one-half of a day to less than one week (3 hours to 29 hours) of SIMMS professional development.

Substantial Native American Population: Thirty-three percent or more of the students are Native American according to data collected by the Office of Public Instruction in the state of Montana.

### Review of the Literature

#### Assessment

In 1988, Crooks published a review of research literature related to assessment practices. He found that assessment affects students by

- reactivating or consolidating prerequisite skills or knowledge prior to introducing new material;
- focusing attention on important aspects of the subject;
- encouraging active learning strategies;
- giving students opportunities to practice skills and consolidate learning;
- providing knowledge of results and corrective feedback;
- helping students to monitor their own progress and develop skills of self evaluation;
- guiding the choice of further instructional or learning activities to increase mastery;
- helping students feel a sense of accomplishment. (p. 443)

Frederiksen (1984) observed that “tests tend to increase the time and effort spent in learning and teaching what the tests measure and . . . decrease efforts to learn and teach skills not measured by the test.” (p. 193) Further, he notes that “If educational tests fail to

represent the spectrum of knowledge and skills that ought to be taught, they may introduce bias against teaching important skills that are not measured.” (p. 193)

It is important to focus on the assessment practices of high school mathematics teachers because research indicates that this group of teachers tends to spend more time assessing students through teacher-made tests than through any other method of assessment. In addition, these tests have a large influence on how high school mathematics teachers evaluate students when determining report card grades. In a nationwide study of teachers, including 363 high school teachers, Herman and Dorr-Bremme (1984) found that on a scale from 1 to 4, where 1 indicates unimportant and 4 indicates crucial importance, secondary school teachers rated teacher-made test at 3.65 in terms of deciding on report card grades. The authors also found that about 76% of the time tenth-grade mathematics teachers devoted to testing was apportioned to administering teacher-made tests. The importance of teacher-made tests to high school teachers was confirmed by Stiggins and Bridgeford (1985) in a nationwide study of 228 teachers in public schools. They concluded that “the higher the grade level, the greater the tendency for teachers to report using their own assessments rather than published tests.” (p. 281)

In 1992, Marso and Pigge published a summary of their review of approximately 225 studies addressing K-12 classroom teachers’ knowledge of skills related to the development and use of teacher-made tests. With regard to teachers’ testing practices, attitudes, and beliefs, the researchers arrived at the following conclusions:

- Teachers rely on teacher-made tests to a much greater extent than standardized tests and district state competency tests for making decisions about individual pupils.
- Teachers believe that self-constructed assessments generally better meet the instructional needs of their classes than do assessments derived from other sources such as workbooks or textbooks.
- Teachers believe that they are less proficient in testing skills when compared to their proficiencies in other professional skill areas.
- Teachers generally report that they have deficiencies in testing and measurement, feel that their self-constructed tests could be improved, and would like inservice [sic] training in tests and measurements if this training were oriented toward practical classroom needs, but they tend to be confident about their general abilities and knowledge.
- Teachers believe that essay tests as compared to objective tests are impractical and disliked by pupils but result in greater study efforts and usually measure at higher cognitive levels.
- Teachers believe that testing, evaluation, and grading activities are among their more demanding and less pleasant classroom responsibilities.
- For most preservice [sic] and inservice [sic] teachers it appears that their knowledge of classroom testing practices and principles is inadequate to meet classroom evaluation needs, and it appears that little progress has been made in overcoming this inadequacy during the past quarter century.
- Neither inservice [sic] training, if provided, nor increased years of teaching experience appear to improve either classroom teachers' testing knowledge or their test construction skills as measured by paper and pencil tests and as revealed by direct analysis of construction flaws found on their self-constructed tests.
- Teachers appear to value the importance of having higher cognitive functioning questions on teacher-made tests, but they infrequently use such questions; they tend to over-estimate the number of higher order questions used on their tests; and they have difficulty identifying and writing test questions that function beyond the knowledge level. (pp. 23-27)

Another study that relates to teachers' assessment practices was conducted by Newman and Stallings (1982). In May of 1980, Newman and Stallings mailed out 1500 questionnaires to K-12 teachers in Atlanta, Georgia, Pensacola, Florida, and Mobile, Alabama for the purposes of determining how well teachers understand classroom testing principles and gain information on the measurement preparation and classroom practices

of teachers. The return rate was approximately 21.5%. The researchers found that "teachers use teacher-made tests extensively and spend a substantial amount of professional time constructing, administering, scoring, and interpreting them." (p. 8) Furthermore, it was concluded that although the data suggest a trend towards more measurement work in teacher training programs, as compared to a study conducted in 1967, this did not translate into a better understanding of classroom testing principles.

### Higher-Order Thinking Skills

Teaching and assessing higher-order thinking is considered a priority by many authors. Cross (1985) believes that the advent of the "information explosion" will require business and industry in the 21st century to place a premium on employees who can synthesize large amounts of information. Daggett (1994) notes that in the 1950's, about 60% of the jobs in the United States were unskilled, whereas recently that percentage has dropped to 35%. By the year 2000 he predicts that only 15% of the jobs in the United States will be unskilled. The skill that Daggett affirms will be in high demand in the future is the ability to transfer knowledge to new situations. He attributes this to the demand of small businesses for workers who can solve problems without procedures to follow or managers to assist them. Reviewing statistics released by the U. S. Department of Labor in November 1995, Daggett (1996) found that the American work force employed by companies with 20 or fewer employees is increasing at an annual rate of 7.5%.

Many educators contend that higher-order thinking skills should be taught and assessed in the public schools. Jones (1988), in his review of the literature on

assessment, states that the Alexander-James Study Group recommended that mathematics and science teachers assess problem-solving and higher-order thinking skills so as to “allow . . . inferences about the thought processes contributing to the answer’ (Alexander & James, 1987, p. 23).” (p. 235) Lohman (1993) stresses that “transfer is an important, if not the most important goal of education” and concludes that “Consequently, one of the most important functions of tests should be to estimate how far students can transfer their learning.” (p. 48) Frederiksen (1994) cites six properties that tests of the future should have: Two of them that pertain to the present discussion are

- It would be ideal if the new tests would collectively assess all of the important aspects of learning, not just factual knowledge. This means that tests should assess problem solving not only in the conventional sense, but also with the relevant underlying skills and abilities that are involved.
- The new tests should encourage generalization of learning. The use of a wide variety of problems in different situations and settings should facilitate transfer to new situations. (p. 534)

Similar statements about the need to assess higher-order thinking are often found in the literature. See, for example (Research into Practice Project, 1984), (Peterson, 1988), or (National Academy of Sciences, 1991).

Stiggins, Rubel, and Quellmalz (1985) wrote, “We believe that the new wave of educational improvement is focusing on the improvement of reasoning skills. These are the new basic skills.” (p. 37) They continue by stating that “One key to the success of these efforts will be each individual teacher’s ability to measure thinking skills in a valid and reliable manner.” (p. 37)

An interesting study that relates instructional goals to the emphasis, by teachers, of higher-order thinking was conducted by Raudenbush, Rowan, and Cheong (1993).

Questionnaires were mailed to all teachers in 16 high schools in the states of California and Michigan to explore variations in emphasis on teaching higher-order thinking in secondary schools. The return rate varied from 50 to 100% with a median of 75%. The researchers concluded that, with respect to emphasis on higher-order thinking, "differentiated instructional objectives are strongly institutionalized in the secondary mathematics and science curricula" (p548) and that there are institutional obstacles to promoting higher-order thinking in secondary mathematics and science.

#### Assessment of Higher-Order Thinking Skills

Several studies between 1983 and 1997 have documented the lack of assessment of higher-order thinking skills through testing in the public schools. A court order for desegregation of the Cleveland school district required a systematic technical analysis of teacher-made tests in the district to determine if they were being developed, administered, scored, and used in a nondiscriminatory manner. Fleming and Chambers (1983) reported that the review process generated information about the technical aspects of 342 (8800 test questions) teacher-made tests in four subject areas (including mathematics), grades 1 through 12, over a two-year period. A second review process classified test questions according to behavioral categories delineated by Bloom (1981): *knowledge of terms; knowledge of facts; knowledge of rules and principles; skill in using processes and procedures; ability to make translations; and ability to make applications*. Eight observations about how teachers test in the Cleveland school district emerged:

1. Teachers use short-answer questions most frequently in their test making.
2. Teachers, even English teachers, generally avoid essay questions.
3. Teachers use more matching items than multiple-choice or true-false items.

4. Teachers devise more test questions to sample *knowledge of facts* than any of the other behavioral categories studied.
5. When categories related to *knowledge of terms*, *knowledge of facts*, and *knowledge of rules and principles* are combined, almost 80% of the test questions reviewed focus on these areas.
6. Teachers develop few questions to test behaviors that can be classified as *ability to make applications*.
7. Comparison across school levels shows that junior high school teachers use more questions to tap *knowledge of terms*, *knowledge of facts*, and *knowledge of rules and principles* than elementary or senior high school teachers (94%, 69%, 69% respectively).
8. At all grade levels, teacher-made mathematics and science tests reflect a diversity of behavioral categories, since they typically feature questions in all six behavioral categories. (p. 32)

Over 73% of the mathematics questions surveyed tested at the levels *knowledge of terms*, *knowledge of facts*, *knowledge of rules and principles*, and *skill in using processes and procedures*. *Ability to make translations* and *ability to make applications* were evaluated by less than 27% of the questions.

Support for the generalization of Fleming and Chambers (1993) observations across not only the nation, but also across subject areas, is found in a study by Carter (1984). This study was conducted using a sample of 310 secondary reading and language teachers from a four-state area in the south central region of the United States. Teachers were given ten multiple-choice items and asked to identify the reading skills that they believed the items were designed to test. They were then given an objective specifying one of four reading skills (main idea, detail, inference, and prediction) for which they were to develop a multiple choice item that assessed for the achievement of that objective. Results of the study indicate that many of the teachers were unable to recognize the particular skill being tested by individual test items. Also, "Teachers spent

more time on and had more difficulty in developing items tapping higher-level skills than writing items to test lower level cognitive skills.” (p. 59)

A study by Ball, Doss, and Dewalt (1986) of 74 social studies teachers in two southeastern states was conducted through a questionnaire and the collection of classroom tests. It was found that “Slightly less than half of the teachers (47%) indicated that higher level objectives were important in their students’ learning and fewer (24%) said they predominantly used higher level objectives in their classroom teaching or indicated they used them when constructing classroom tests (26%).” (p. 29) It was found that the vast majority of test questions on classroom tests (from 95.6 to 99.7%) assessed lower-level objectives.

Utilizing interviews, observations, and samples of teachers’ assessment instruments, Stiggins, Griswold, and Wikelund (1989) gathered data on the assessment practices of 36 volunteer teachers (grades 2-12) in a suburban school district in the northwestern region of the United States. The study focused on four content areas: mathematics, science, social studies, and language arts. Besides other methods of data collection, the researchers asked the teachers to provide four to six samples of paper and pencil assessments recently used in their classroom. It was determined that although the vast majority of teachers had been trained to teach higher-order thinking skills, fewer than one-third had participated in more than one training session in the assessment of higher-order thinking skills and one-third had not received any training at all in this area. Training in the assessment of higher-order thinking skills was found to be more common among teachers at the middle and high school level. The largest percentage of test items

collected by the investigators (approximately 46%) tested for recall of facts and information; *Knowledge* and *Comprehension* according to Bloom's taxonomy. This pattern was consistent across grade levels. If we focus only upon the mathematics test items we find that 19% of the items tested for recall (*Knowledge* according to Bloom's taxonomy), nine percent tested for comparison (*Analysis* according to Bloom's taxonomy) and all of the rest (72%) tested for inference (*Application* and *Synthesis* according to Bloom's taxonomy). The later results (categorization of mathematics test items) seem inconsistent with other research. This may be explained by the observation that the researchers considered a problem to be higher-order if a student was expected to solve a problem without being prompted by the teacher for the required steps needed to solve the problem. The researchers considered professional development that focuses on the assessment of higher-order thinking skills, a critical factor in changing teachers' assessment practices.

A study by Cooney (1992) was conducted to provide a basis for understanding the nature of secondary mathematics teachers' (grade 7-12) evaluation practices. The study consisted of three phases: the administration of a questionnaire aimed at obtaining general information about teachers' assessment practices, a second questionnaire that focused on soliciting teachers' reactions to five non-traditional assessment items, and an interview with selected teachers. Copies of the Phase I questionnaire were sent to all instructors in the State of Georgia who were teaching Eisenhower Plan supported mathematics or mathematics education courses for teachers. Two hundred and seventy-nine teachers responded to the Phase I questionnaire and of these, 201 teachers taught mathematics in

grades 7-12. Phase II questionnaires were sent to the 201 teachers who had completed the first questionnaire and taught mathematics in grades 7-12. Of those, 102 completed the questionnaire. Twenty of the 102 teachers completing the second questionnaire were selected to be interviewed at their schools, but only 18 could participate. The teachers who were selected to be interviewed reflected a wide range of evaluation practices, varied responses to the Phase II questionnaire, and different geographical and school settings.

The Phase I questionnaire was designed to provide descriptive information about the contexts in which the teachers taught the previous school year (1989-1990), the nature of their assessment practices, the importance attributed to different purposes for assessment, and their perception of how math is learned. As part of the first questionnaire, teachers were asked to write or draw a typical problem that they had given their students that they believed tested for a minimal understanding of the topic. Similarly, they were asked to do the same thing for a typical problem that they believed tested for a deep and thorough understanding of the topic. Their responses were categorized using the following four levels:

1. Simple computation or recognition;
2. Comprehension. Students must make some decision but once made the solution process is straightforward, e.g., a simple one step problem;
3. An application or multistep problem in which [the] student must make several decisions about [the] solution process or what operations to use; and
4. Nonroutine or open-ended problem. (Cooney, 1992, p. 7)

In addition, teachers were asked to give a rating ranging from 1 (very important) to 5 (of no importance) to the following purposes of assessment:

1. Certify level of mathematical competence
2. Identify students' misconceptions
3. Provide feedback to students on [their] progress

4. Help students organize knowledge
5. Increase students' motivation to learn
6. Assist teachers in keeping students on task. (p. 10)

The Phase II questionnaire presented five non-traditional items and asked the teachers to construct an ideal response, identify the mathematical content and processes each item assessed, indicate the likelihood that they would use the items with their students, and describe the type of student or class for which they would most be inclined to use the items. The interview protocol was developed to obtain more detailed information about the teachers' responses to the first two questionnaires.

It was found that only 2 of the 18 teachers interviewed had any substantial knowledge of the NCTM Curriculum and Evaluation Standards for School Mathematics (1989) (henceforth referred to as the Standards) and none of the teachers had any knowledge of the Evaluation section of the Standards. Cooney suggested that the Standards be used as a leverage point for teacher education programs. There is evidence from this study that many teachers are assessing students on a narrow range of outcomes such as computations and one-step problems. A high proportion (57%) of the teachers in the study equated a deeper understanding of mathematics with the ability to perform difficult computations or to solve one-step problems. Less experienced teachers were less likely to write Level 3 or Level 4 items to test for a deep and thorough understanding than their experienced counterparts. The author suggested that beginning teachers receive some sort of pre-service or in-service training that focuses on generating such questions. Teachers liked the non-traditional test items in the second questionnaire that required the generation of a specific number more than the test items that required an explanation or

the generation of a counterexample. They rationalized this preference by expressing concern about the time that it would take to grade more open-ended questions. Other frequently mentioned concerns were

1. Students' ability to read and write are [sic] too low to profit from responding to such items.
2. Students have poor thinking skills.
3. Students have short attention spans. (Cooney, 1992, p. 17)

Teachers indicated that the most important purposes of assessment are to certify competence, identify misconceptions so that instruction can be adjusted, and to provide feedback to students on their progress.

Cooney concluded that skill performance, rather than conceptual understanding, is what many teachers associate with mathematical competence and that reform in the mathematics classroom is not a widespread phenomena and is not likely to become one unless significant in-service programs are provided. He asserted that teachers need to see mathematics as more than just a sequence of well-defined steps. A final observation made by the author was that we cannot expect reform in mathematics education to occur in the absence of assessment methods that reflect a broader view of mathematics.

Students and teachers must see mathematics as a science of reasoning, posing and solving problems, and as a means of communication.

The most recent study of assessment practices by high school mathematics teachers was conducted by Senk, Beckmann, and Thompson (1997). Nineteen classes in five high schools in three Midwestern cities were studied utilizing data obtained from questionnaires and the collection of all written assessment instruments used in each classroom. It was determined that "the most frequently used assessment tools were tests

and quizzes, with these determining about 77% of students' grades." (p. 187) In common with the majority of the other studies of classroom tests mentioned above, tests items, generally, "were low level, were stated without reference to a realistic context, involved very little reasoning, and were almost never open-ended." (p. 187) It is interesting to note that the "teachers' knowledge and beliefs, as well as the content and textbook of the course, influenced the characteristics of test items and other assessment instruments." (p. 187)

### Professional Development

In each of the studies reviewed in the previous section, the authors suggested that teachers receive further training in assessment either through pre-service instruction or professional development. Fielding and Shaughnessy (1990) conducted a study of the impact of professional development using teachers from ten high schools, two from each of five school districts in western Oregon. The goal of their program was to enhance high school science teachers' skills in designing and using tests as aids to instruction. Teachers from five of the schools participated in school-based workshops whereas teachers from the other five schools received no training. Based upon informal comments and written responses from teachers who participated in the workshops, the workshops were considered a success. A subsequent impact analysis utilizing student and teacher interviews and classroom observations revealed that there were no clear differences between teachers whom had received training and those who had not. This was attributed, initially, to the limited training time and follow-up support. However, the researchers did not consider this an adequate explanation. They concluded that the

demands of classroom management, the curriculum's overemphasis on content coverage, and a lack of organizational commitment on the part of the schools, rather than inadequacies in the training program, resulted in their training program having little or no lasting impact upon the assessment practices of teachers in the experimental group.

In 1989, Sparks and Loucks-Horsley organized what was then known about professional development into five models:

1. Individually-Guided Staff Development
2. Observation/Assessment
3. Involvement in a Development/Improvement process
4. Training
5. Inquiry

The SIMMS Project introduced Montana mathematics teachers to the SIMMS IM curriculum by utilizing three of those models: Involvement in a Development/Improvement Process, Training, and Observation/Assessment. The SIMMS Project, over a four-year period (1992-1996), employed approximately 70 teachers to help develop the SIMMS IM curriculum. In addition, about 80% of all high school mathematics teachers in the state of Montana have received some degree of SIMMS IM professional development through workshops, seminars, summer institutes, extended studies courses, and in-service programs. (SIMMS Project, Summer, 1997, p. 10) Initially, when the curriculum was introduced into high school classrooms, site visits were used to provide feedback to participating teachers. Unlike the professional development program utilized by Fielding and Shaughnessy, the SIMMS Project has provided several Montana teachers with extensive professional development related to the SIMMS IM curriculum.

### Theoretical Framework

Studies conducted by Fleming and Chambers (1983); Carter (1984); Ball, Doss, and Dewalt (1986); Stiggins, Griswold, Green, and Associates (1987); Cooney (1992); and Senk, Beckmann, and Thompson (1997) indicate that, generally speaking, higher-order thinking skills are not being assessed by teacher-made tests in the public schools. With the exception of both Carter and Cooney, all of those studies focused on the tests and quizzes that teachers used to assess their students. Teachers were not asked to specifically generate a question that assessed higher-order thinking skills. Hence, we cannot determine if teachers have the ability to write questions for their students that assess higher-order thinking skills. In addition, with the exception of the study by Cooney (1992), the research literature does not indicate what factors may affect the levels at which public high school mathematics teachers assess their students. Cooney categorized teacher-made questions according to a taxonomy, created specifically for the study, based upon Bloom's taxonomy and related those results to the teachers' teaching experience.

Bloom (1956) established a theoretical framework for categorizing assessment questions according to behaviors that students were asked to demonstrate. Cooney modified this taxonomy for use in categorizing teacher-made mathematical problems and related those categories to teachers' teaching experience to determine if there was a pattern or relationship. The theoretical framework of this study was based upon this

aspect of Cooney's research. This study utilized research methods similar to Cooney's (questionnaires and interviews) with two substantial differences:

1. Statistical comparison and test of relationship were used to analyze the data.
2. Other factors besides teaching experience were tested for relationship to the levels of the problems that teachers wrote.

This study is significant in that it focuses on factors that are directly or indirectly affected by mathematics educators and utilizes statistical techniques to determine if those factors relate to the assessment of higher-order thinking skills by high school mathematics teachers in the state of Montana. This information is necessary for determining the type and content of classes that should be used to prepare high school mathematics teachers so that they have available working-knowledge of how to assess higher-order thinking skills in their classroom.

## CHAPTER 2

## METHODOLOGY

Quantitative Research MethodologyPopulation Description and Sampling Procedure

The population for this study was all full-time mathematics teachers in the state of Montana who teach grades nine through twelve in the public high schools. It was originally estimated, based upon the SIMMS Integrated Mathematics Implementation Schools Directory (1997-1998), that there were approximately 576 teachers in the state of Montana teaching mathematics in grades nine through twelve in the public high schools during the 1997-1998 school year and that 30 to 35% of those teachers used SIMMS IM curriculum materials in their classrooms.

Base upon those estimates, 234 teachers from the population described above were selected to participate in this study using a stratified random sample. The sample size was determined by calculating the size of a sample required for a 95 percent degree of accuracy using the formula published by Krejcie and Morgan (1970, p. 607). Midway through the process of collecting the questionnaires, it was determined that the estimate of 576 secondary high school mathematics teachers in the state of Montana was too high since several of the teachers who responded did not meet the criteria of the study. A better estimate for the population of the study would be somewhere between 475 and 500

teachers with a sample size of between 215 to 220 teachers to obtain a 95% degree of accuracy. A simple computation, based upon returned questionnaires, indicated that approximately 35 of the teachers receiving the questionnaire did not meet the criteria of the study so it was decided to add another group of 21 randomly selected teachers to the original sample.

Seven categories of teachers were randomly sampled in proportion to the ratio of the number of teachers in each category to the total population of teachers being sampled. Those categories, as determined by the Office of Public Instruction in the state of Montana, were:

1. Teachers who teach at a Class C high school with a substantial Native American population (see p. 8 for the definition of Substantial Native American Population)
2. Teachers who teach at a Class C high school that does not have a substantial Native American population
3. Teachers who teach at a Class B high school with a substantial Native American population
4. Teachers who teach at a Class B high school that does not have a substantial Native American population
5. Teachers who teach at a Class A high school with a substantial Native American population
6. Teachers who teach at a Class A high school that does not have a substantial Native American population

7. Teachers who teach at a Class AA high school that does not have a substantial Native American population

There are, presently, no Class AA public high schools with a substantial Native American population in the state of Montana.

#### Null Hypotheses to be Tested

It should be noted that any reference to the categorization of teacher's written questions, for the purpose of this study, is in terms of Cooney's taxonomy. In addition to determining the number and percent of public high school mathematics teachers in the state of Montana who wrote Level 1, Level 2, Level 3, and Level 4 questions, this study tested the following null hypotheses:

1. There is no significant difference between the mean number of hours of professional development for teachers who wrote Level I, Level II, Level III, or Level IV questions as examples of questions that test for higher-order thinking skills.
2. There is no significant difference between the mean number of years teaching mathematics for teachers who wrote Level I, Level II, Level III, or Level IV questions as examples of questions that test for higher-order thinking skills.
3. There is no relationship between the categorization of teachers' written examples of questions that test for higher-order thinking skills and the amount of SIMMS professional development that they have received.
4. There is no relationship between the categorization of teachers' written examples of questions that test for higher-order thinking skills and the use of the SIMMS IM curriculum in their classroom.

5. There is no relationship between the categorization of teachers' written examples of questions that test for higher-order thinking skills and the number of credit hours that they have accumulated from college classes in assessment or evaluation.
6. There is no relationship between the categorization of teachers' written examples of questions that test for higher-order thinking skills and the highest academic degree they have obtained.
7. There is no relationship between the categorization of teachers' written examples of questions that test for higher-order thinking skills and which educational objective from Bloom's taxonomy they rank most important in their classroom.

#### Categorization of Variables

Categories for Level 1, Level 2, Level 3, and Level 4 questions were sometimes combined when utilizing a chi-square test of independence so that there would be no zeroes in the matrix. This was done by combining Levels 1 and 2 (lower-order objectives) and Levels 3 and 4 (higher-order objectives), respectively.

The variables for Null Hypothesis 1 were *categorization of the teacher's question* and *amount of professional development*. The former variable was categorized in the following way:

1. Teachers who wrote a Level 1 question as an example of a question that assesses higher-order thinking skills
2. Teachers who wrote a Level 2 question as an example of a question that assesses higher-order thinking skills

3. Teachers who wrote a Level 3 question as an example of a question that assesses higher-order thinking skills
4. Teachers who wrote a Level 4 question as an example of a question that assesses higher-order thinking skills

The variables for Null Hypothesis 2 were *categorization of the teacher's question* and *years of experience teaching mathematics*. The former variable was categorized in the following way:

1. Teachers who wrote a Level 1 question as an example of a question that assesses higher-order thinking skills
2. Teachers who wrote a Level 2 question as an example of a question that assesses higher-order thinking skills
3. Teachers who wrote a Level 3 question as an example of a question that assesses higher-order thinking skills
4. Teachers who wrote a Level 4 question as an example of a question that assesses higher-order thinking skills

The variables for Null Hypothesis 3 were *categorization of the teacher's question* and *amount of SIMMS professional development*. The former variable was categorized in the following way:

1. Teachers who wrote a Level 1 question as an example of a question that assesses higher-order thinking skills
2. Teachers who wrote a Level 2 question as an example of a question that assesses higher-order thinking skills

3. Teachers who wrote a Level 3 question as an example of a question that assesses higher-order thinking skills
4. Teachers who wrote a Level 4 question as an example of a question that assesses higher-order thinking skills

The latter variable was categorized in the following way:

1. Teachers who are either SIMMS IM introduced or Non-SIMMS IM
2. Teachers who are either SIMMS IM certified or SIMMS IM trained

The variables for Null Hypothesis 4 were *categorization of the teacher's question and use of the SIMMS IM curriculum in the classroom*. The former variable was categorized in the following way:

1. Teachers who wrote a Level 1 or Level 2 question as an example of a question that assesses higher-order thinking skills
2. Teachers who wrote a Level 3 or Level 4 question as an example of a question that assesses higher-order thinking skills

The latter variable was categorized in the following way:

1. Teachers who use SIMMS IM curriculum materials exclusively in one or more of their classrooms and are either SIMMS IM certified or SIMMS IM trained
2. Teachers who use SIMMS IM curriculum materials exclusively in one or more of their classrooms and are either SIMMS IM introduced or Non-SIMMS IM, teachers who use SIMMS IM curriculum materials in their classrooms in conjunction with another textbook or curriculum, or teachers who do not use

SIMMS curriculum materials in their classroom and are either SIMMS IM certified or SIMMS IM trained

3. Teachers who do not use SIMMS curriculum materials in their classrooms and are either SIMMS IM introduced or Non-SIMMS IM

By splitting teachers into these three categories the influence of SIMMS professional development on those teachers who do not teach using the SIMMS IM curriculum was controlled.

The variables for Null Hypothesis 5 were *categorization of the teacher's question* and *number of credit hours*. The former variable was categorized in the following way:

1. Teachers who wrote a Level 1 or Level 2 question as an example of a question that assesses higher-order thinking skills
2. Teachers who wrote a Level 3 or Level 4 question as an example of a question that assesses higher-order thinking skills

The latter variable was categorized in the following way:

1. Teachers who have accumulated zero to three credit hours for college classes in assessment or evaluation
2. Teachers who have accumulated from four to six credit hours for college classes in assessment or evaluation
3. Teachers who have accumulated seven or more credit hours for college classes in assessment or evaluation

The variables for Null Hypothesis 6 were *categorization of the teacher's question* and *highest academic degree obtained*. The former variable was categorized in the following way:

1. Teachers who wrote a Level 1 or Level 2 question as an example of a question that assesses higher-order thinking skills
2. Teachers who wrote a Level 3 or Level 4 question as an example of a question that assesses higher-order thinking skills

The latter variable was categorized in the following way:

1. Teacher who have obtained a baccalaureate degree
2. Teachers who have obtained either a master or a doctor degree

The variables for Null Hypothesis 7 were *categorization of the teacher's question* and *highest ranked educational object from Bloom's taxonomy*. The former variable was categorized in the following way:

1. Teachers who wrote a Level 1 or Level 2 question as an example of a question that assesses higher-order thinking skills
2. Teachers who wrote a Level 3 or Level 4 question as an example of a question that assesses higher-order thinking skills.

The latter variable was categorized in the following way:

1. Knowledge
2. Comprehension
3. Application
4. Analysis

5. Synthesis
6. Evaluation

#### Method of Data Collection

To gather the data for this study, questionnaires were mailed to 234 randomly selected full-time high school mathematics teachers in the state of Montana during the fall of 1998. As explained above, 21 randomly selected teachers were added to the sample and mailed questionnaires during the winter of 1998. The Total Design Method (TDM), as outlined by Dillman (1978), was utilized. This entailed sending

- a postcard to each teacher announcing that they had been selected for the study and would receive a questionnaire in one week;
- a cover letter and questionnaire one week after the postcard was sent;
- a postcard reminder to all 255 teachers one week after the questionnaire was sent;
- a cover letter and replacement questionnaire to all non-responders four weeks after the reminder was sent;
- a final mailing of a cover letter and replacement questionnaire to all non-responders three weeks after the second questionnaire was sent.

Non-responders from among the 21 teachers who were subsequently added to the sample received only one replacement questionnaire; not two, as were some non-responders in the original sample. Dillman examined 38 surveys that used the TDM either completely or in part and found that those surveys that used the TDM completely on a specialized

population obtained an average response rate of 81%. Those that used the TDM completely on the general population obtained an average response rate of 73%. (p. 27)

The questionnaire designed for this study was targeted at the specialized population described above.

### Reliability and Validity

The questionnaire for this study required teachers to provide the following information:

- Write two questions; one that they would give their students to assess higher-order thinking skills and another that they would give to assess lower-order thinking skills;
- Determine the approximate amount of professional development they have received from 1996 to 1998 and the amount of SIMMS professional development they had received from 1992 to 1998;
- List the textbooks that they use in their classroom;
- Rank-order a list of educational objectives;
- Indicate the number of years they have taught mathematics in the public schools and the total number of years that they have taught;
- Indicate the highest degree they have received and the subject area for which they received that degree;
- Indicate the number of credit hours they have accumulated from classes in assessment or evaluation at the college level.

Please refer to the copy of the original questionnaire in Appendix A.

Two aspects of reliability were addressed: First, the reliability of the questionnaire and second, the reliability of the categorization of question Q2a by the researcher.

Reliability of the questionnaire was established through a test/retest conducted over a four-week period, in the winter of 1998, involving seven high school mathematics teachers. Originally, nine teachers were scheduled to participate, but two did not return the first questionnaire. The results of this test/retest are shown in Table 1.

Table 1. Results of Test/Retest

Question Number	Teacher 1		Teacher 2	
	Test	Retest	Test	Retest
Q-2a	Cooney 3	Cooney 4	Cooney 4	Cooney 2
Q-4	500 hrs.	600 hrs.	375 hrs.	320 hrs.
Q-5	SIMMS Certified	SIMMS Certified	SIMMS Certified	SIMMS Certified
Q-6	SIMMS Curriculum	SIMMS Curriculum	Mixed Curriculum	Mixed Curriculum
Q-7	Bloom 3	Bloom 3	Bloom 5	Bloom 2
Q-8	4 Years	4 Years	9 Years	9 Years
Q-9	4 Years	4 Years	8 Years	8 Years
Q-10	10,11,12	9,10,11,12	9,10,11,13	9,10,11,12
Q-11	Bachelor	Bachelor	Bachelor	Bachelor
Q-12	Math Ed.	Math Ed.	Math	Math
Q-13	4-6 Credits	7 or More Credits	0-3 Credits	0-3 Credits
	Teacher 3		Teacher 4	
Q-2a	Cooney 2	Cooney 2	Cooney 2	Cooney 2
Q-4	30 hrs.	8 hrs.	520 hrs.	520 hrs.
Q-5	SIMMS Introduced	SIMMS Introduced	SIMMS Certified	SIMMS Certified
Q-6	Mixed Curriculum	Mixed Curriculum	Non- SIMMS Curriculum	Non- SIMMS Curriculum
Q-7	Bloom 6	N/A	Bloom 6	Bloom 6
Q-8	2 Years	2 Years	7 Years	7 Years
Q-9	2 Years	2 Years	5 Years	5 Years
Q-10	9,10,11	9,10,11,12	9,10,11	9,10,11
Q-11	Bachelor	Bachelor	Bachelor	Bachelor
Q-12	Math and Other	Math and Other	Math Ed.	Math Ed.
Q-13	4-6 Credits	0-3 Credits	4-6 Credits	4-6 Credits

Table 1 Results of Test/Retest (Continued)

Question Number	Test	Retest	Test	Retest
	Teacher 5		Teacher 6	
Q-2a	Cooney 3	Cooney 3	Cooney 3	Cooney 3
Q-4	135 hrs.	348 hrs.	350 hrs.	210 hrs.
Q-5	Non-SIMMS	Non-SIMMS	SIMMS Certified	SIMMS Certified
Q-6	N/A	N/A	Non-SIMMS Curriculum	Non-SIMMS Curriculum
Q-7	Bloom 6	Bloom 6	Bloom 6	Bloom 6
Q-8	18 Years	22 Years	7 Years	7 Years
Q-9	12 Years	11 Years	7 Years	7 Years
Q-10	N/A	N/A	9,10,11,12	9,10,11,12
Q-11	Master	Master	Bachelor	Bachelor
Q-12	Other	Other	Math Ed.	Math Ed.
Q-13	4-6 Credits	4-6 Credits	4-6 Credits	7 or More Credits
	Teacher 7			
Q-2a	Cooney 2	Cooney 2		
Q-4	60 hrs.	20 hrs.		
Q-5	Non-SIMMS	Non-SIMMS		
Q-6	Non-SIMMS Curriculum	Non-SIMMS Curriculum		
Q-7	Bloom 1	Bloom 2		
Q-8	4 Years	3 Years		
Q-9	4 Years	3 Years		
Q-10	10,11,12	10,11,12		
Q-11	Bachelor	Bachelor		
Q-12	Math and Math Ed.	Math Ed.		
Q-13	4-6 Credits	0-3 Credits		

There were some discrepancies between the test and retest for most of the teachers. For question Q-2a, Teachers 1 and 2 had a discrepancy. The discrepancy for Teacher 1 was one level on Cooney's taxonomy. Questions at both levels 3 and 4 assess

higher-order thinking skills and therefore this discrepancy is not serious. The discrepancy for Teacher 2, on the other hand, is large (from 4 to 2). This may be explained by the fact that the teacher did not originally write a question for the retest and, when subsequently asked to, hurriedly wrote one and sent it in the mail.

There were several discrepancies for question Q-4. The differences in hours between the test and retest range from 0 to 213 hours with an average of about 81 hours per teacher, or 27 hours per year.

Teachers 2 and 7 had a discrepancy on question Q-7 while Teacher 3 failed to complete it on the retest. It was decided to rewrite this question and conduct a test/retest during the summer of 1998. This will be discussed below.

Only Teacher 5 was inconsistent on questions Q-8 and Q-9. Teacher 5 also had taught longer than any of the other teachers and may have forgotten exactly how many years she has taught.

Teachers 1 and 3 were inconsistent on question Q-10. On the first questionnaire, Teacher 1 commented that he had also taught grade 9 for three years. This may have been the reason that it was included on the retest. Teacher 3 should not have made the same mistake since he was teaching at the same time that he completed the questionnaire. It should be noted that this teacher included a comment on his retest stating that "these questionnaires are getting annoying."

Four teachers were inconsistent on question Q-13. Teachers 1 and 6 were taking courses that included an assessment component during the semester that they completed the questionnaires and may have therefore included those credits on the retest. Teacher 3

appears to have filled out the retest in a hurried manner. This may account for the inconsistency. The inconsistency of Teacher 7 cannot be explained.

After completing the questionnaire for the first time, the teachers who participated in the test/retest were asked to complete a survey evaluating the questionnaire. Teacher 1 suggested that the instructions for question Q-13 indicate that only classes in assessment or evaluation should be considered and that question Q-11 include the option "currently working on an advanced degree". This was one of the teachers who were taking courses during the semester that they completed the questionnaires. Teacher 2 thought that the option "other" should be included in question Q-5. Teacher 7 commented that the questionnaire was "a little verbose" and that this made it hard to read every word. The same teacher thought that the instructions for questions Q-4 and Q-5 should specify whether or not pre-teaching experience should be included in the number of hours of professional development. These suggestions were taken under consideration and appropriate changes were made.

As stated above, question Q-7 was rewritten and piloted during the summer of 1998. Ten students attending a graduate course for mathematics teachers (Advanced Teaching Strategies) were asked to rank-order the six items. Three weeks later they were again asked to rank-order the items. The results are shown in Table 2. Three of the ten students were inconsistent. Several of the students had trouble interpreting the meaning of the words "analyze" and "synthesize". It was therefore decided to replace these words with "breakdown" and "combine", respectively; both of which come directly from the condensed version of Bloom's taxonomy (Bloom, 1956, pp. 205-206).

Table 2. Test/Retest Results for Revised  
Question Q-7

Student	Objective Selected as First	
	Test	Retest
1	Bloom 6	Bloom 4
2	Bloom 5	Bloom 5
3	Bloom 6	Bloom 3
4	Bloom 3	Bloom 3
5	Bloom 3	Bloom 3
6	Bloom 3	Bloom 3
7	Bloom 3	Bloom 5
8	Bloom 3	Bloom 3
9	Bloom 6	Bloom 6
10	Bloom 5	Bloom 5

Members of the researcher's committee and mathematics educators from Montana State University determined the validity of the questions used in the questionnaire. To obtain reliability in categorizing the teacher-generated problems (question Q-2a), the researcher and his committee Co-Chair (Dr. Maurice Burke) trained in classifying exam questions using questions submitted by teachers for the test/retest described above. A rubric for categorizing questions was designed based upon Cooney's taxonomy and guidelines suggested by Bloom (1956). Dr. Burke and the researcher independently categorized 40 randomly selected teacher-generated problems from the questionnaires. After this was completed, an interclass correlation (ICC) was computed, based upon a method outlined by Futrell (1995, pp. 81-86). This method was designed to estimate the reliability of two or more judges' averaged ratings. Any value lower than a 0.7 is considered unacceptable, whereas a value higher than 0.9 is considered excellent. An ICC of 0.836 was computed for the 40 questions categorized by Dr. Burke and the researcher. Fleming and Chambers (1983) found that agreement between judges, when

categorizing according to Bloom's taxonomy, could be achieved in 85% or more of the classifications through explanation and practice. The reliability of the classification of data from the other questions (Q-4 through Q-13) was obtained by designing the categories so that they were mutually exclusive.

Another form of reliability, pertaining to the classification of teacher-generated problems, must be discussed. Schrag (1989) states that "... whether a task requires higher-order thinking depends on the resources of the thinker." (p. 530) Before we can categorize a problem using either Cooney's or Bloom's taxonomy, we must know what the students already knows and what types of problems were assigned to the students by the teacher. The problem was addressed in this research by requiring the teacher to indicate the specific class and curriculum unit for which the question was designed. Both Dr. Burke and the researcher found this information vital for categorizing the problems and helpful in resolving most differences in categorization encountered during the test of reliability.

The validity of Cooney's taxonomy follows from the validity of Bloom's taxonomy. Cooney's taxonomy has the following categories:

Level 1. Simple computation or recognition;

Level 2. Comprehension. Students must make some decision but once made the solution process is straightforward, e.g., a simple one step problem;

Level 3. An application or multistep problem in which [the] student must make several decisions about [the] solution process or what operations to use; and

Level 4. Nonroutine or open-ended problem. (Cooney, 1992, p. 7)

This taxonomy was developed directly from Bloom's taxonomy (Bloom, 1956), but focuses only on mathematical objectives. Level 1 is associated with Bloom's category *Knowledge*, Level 2 is associated with Bloom's category *Comprehension*, Level 3 is associated with Bloom's category *Application*, and Level 4 encompasses Bloom's three categories: *Analysis*, *Synthesis*, and *Evaluation*. Hence, the validity of this taxonomy is directly related to the validity of Bloom's taxonomy. Furthermore, this taxonomy has already been applied to research on teacher-made questions and the results were published over five years ago.

As noted above, the researcher designed a rubric to help categorize teachers' questions using Cooney's taxonomy. This rubric (see Appendix B) was designed using Bloom's taxonomy (1956) as a guide and was expanded and refined based upon the categorization of teacher-generated questions by both Dr. Burke and the researcher. This process was completed before the reliability test, discussed above, was administered.

### Research Design and Analytical Techniques

There are both rural and non-rural schools in Montana with varying percentages of Native American students. These variables were controlled through the use of a stratified random sample.

Each null hypothesis in this study was tested with an  $\alpha = .05$ . This, rather than an  $\alpha = .01$ , was selected since the SIMMS IM curriculum and SIMMS professional development programs have already been introduced into the state of Montana and the costs for their design and development have already been accrued. Therefore, the decision by any school system to incorporate the SIMMS IM curriculum as a result of this

study will be no more expensive than the decision to incorporate any other new curriculum.

The following null hypotheses were tested using the chi-square test of independence:

3. There is no relationship between the categorization of teachers' written examples of questions that test for higher-order thinking skills and the amount of SIMMS professional development that they have received.
4. There is no relationship between the categorization of teachers' written examples of questions that test for higher-order thinking skills and the use of the SIMMS IM curriculum in their classroom.
5. There is no relationship between the categorization of teachers' written examples of questions that test for higher-order thinking skills and the number of credit hours that they have accumulated from college classes in assessment or evaluation.
6. There is no relationship between the categorization of teachers' written examples of questions that test for higher-order thinking skills and the highest academic degree they have obtained.
7. There is no relationship between the categorization of teachers' written examples of questions that test for higher-order thinking skills and which educational object from Bloom's taxonomy they rank most important in their classroom.

The following null hypotheses were tested using an analysis of variance (ANOVA):

1. There is no significant difference between the mean number of hours of professional development for teachers who wrote Level I, Level II, Level III, or Level IV questions as examples of questions that test for higher-order thinking skills.
2. There is no significant difference between the mean number of years teaching mathematics for teachers who wrote Level I, Level II, Level III, or Level IV questions as examples of questions that test for higher-order thinking skills.

### Qualitative Research Methodology

#### Purpose of the Qualitative Research

The purpose of the qualitative research was to assist in the interpretation and explanation of the quantitative data. Generating hypotheses as to why teachers assess the cognitive levels that they do in the classroom helped the researcher interpret the statistical results obtained from the data provided by the questionnaire.

#### Population and Sampling Procedure

The population for the qualitative research was the 59 teachers who indicated on their return postcard that they would be willing to participate in an interview. A stratified sample (the same stratification as used for the quantitative portion of this study) of those 59 teachers was used for this phase of the research. Only two teachers from schools with a substantial Native American population would agree to be interviewed.

### Methods of Data Collection

Data was collected through telephone interviews and by obtaining at least three tests from each teacher that they had actually used in their classroom. The interview protocol was piloted on two teachers from Belgrade High School and one teacher from Park Senior High School in Livingston. Below is a list of the questions that each teacher was asked to respond to during the interview.

1. Describe the types of test questions used by your high school mathematics teachers to assess your understanding of mathematics.
2. Describe the types of test questions used by your college mathematics teachers to assess your understanding of mathematics.
3. List one, two, or at most three factors that have most influenced the way that you assess your students and explain how they have influenced your assessment practices.
4. To gain more detail about your assessment practices in the classroom, describe to me other methods than regular classroom tests that you use to assess your students understanding of mathematics.
5. In order of importance, list which methods of assessment provide the most weight when you eventually assign a letter grade to a student's performance in the classroom.
6. Presently, there is discussion in the education journals of assessment of higher-order thinking skills, relative to Bloom's taxonomy. As an expert in

your field, comment upon the feasibility of assessing your students at levels three through six of the taxonomy.

7. At which levels of Bloom's taxonomy, do you believe that your classroom tests assess your students?

Each teacher was provided with a list of the questions in advance so that they could think about their answers. They were also provided with an abbreviated Taxonomy of Educational Objectives (Bloom, 1956, pp. 201-207) and a postage-paid envelope in which to mail copies of three tests they had used in their classroom.

Interviewing methods, as suggested by Patton (1990, pp. 277-368), were used during the study. The interviews were taped and transcribed and each teacher was made aware of the potential use of their interviews in a future dissertation.

Each teacher was asked to circle those questions on his/her tests that he/she believed assessed higher-order thinking skills and indicate the general aptitude (high, medium, low) of the students in that particular class.

### Research Design

Each teacher selected for the qualitative aspect of this study was treated as a separate case study. The case study was written so that it included the following information:

1. The highest degree obtained by the teacher
2. The teacher's years of experience teaching in a public school
3. The amount of SIMMS professional development received by the teacher
4. Technology available to the students in the classroom

5. The teacher-perceived aptitude of his/her students relative to each different test obtained from the teacher
6. A transcription of the teacher's interview

### Limitations of the Study

Of the 255 questionnaires sent out to teachers in the state of Montana, 145 were returned by the end of the second week of February, 1999; the cutoff date for accepting returned questionnaires. Thirty-five of the returned questionnaires came from teachers who did not teach mathematics and/or did not teach in a high school. Four teachers who did return the questionnaire and were eligible for inclusion in the study did not complete question Q-2 and therefore data from their questionnaire could not be used in this study. If we exclude the 35 teachers who were not eligible for inclusion in this study, then the return rate was exactly 50% (110 out of 220).

Return rate was a serious concern during this study. Several factors contributed to this problem. The list of the public high school mathematics teachers used in this study came from the SIMMS Integrated Mathematics Implementation Schools Directory, 1997-1998. Unfortunately, this directory included several teachers who did not teach mathematics or did not teach in a high school. In addition, at least six teachers did not return the questionnaire either because they had retired, moved, or passed away before or during the study.

To better understand the reasons for the low return rate and to determine if non-responders would provides significantly different data than those who did respond, 32

teachers were randomly selected from a list of teachers who had not returned their questionnaires. Mathematics educators from the Department of Mathematics at Montana State University-Bozeman contacted them by telephone and asked why they had not returned the questionnaire and if they would consider returning it in the near future. Eight teachers (25%) did not return the questionnaire because they were either too busy or had a negative attitude towards mathematics education in general. None of those teachers would agree to return the questionnaire. Three of the teachers contacted (approximately 9%) were not eligible for participation in this study while seven others (approximately 22%) had moved. Fourteen teachers (approximately 44%) said that they had been too busy to complete the questionnaire, but agreed to complete it if sent another copy. Only five of them returned a completed questionnaire.

The information above indicates that almost one-third of the questionnaires may have been sent to teachers who had moved or were not eligible for participation in this study. It also indicates that over two-thirds of the teachers who did not respond may have been too busy, considered the questionnaire a low priority, and therefore failed to complete and return it to the researcher.

The low return rate for the questionnaires combined with a small response to the follow-up by non-responders means that the results of this study cannot be generalized to the population of public high school mathematics teacher in the state of Montana. The reason for this is that the study only reflects the assessment practices of those teachers who were willing to take the time to reveal their assessment practices to the researcher.

Four teachers, who were not part of the original sample, completed and returned questionnaires originally meant for teachers who had either moved or retired at the end of the previous school year (1997-1998). This was not considered a serious problem since the four teachers who filled out the questionnaires met the criteria for eligibility in the study.

Another concern during this study was the accuracy of the responses to question Q-4, which asked teachers to estimate the number of hours of professional development that they had received over a three-year period. The test/retest found an average discrepancy of 27 hours per teacher per year. This discrepancy should be taken into consideration when interpreting the results of analysis of variance since it may significantly impact the variance within or between groups being tested and therefore the *F*-value computed by the analysis of variance.

#### Delimitations of the Study

Most of the data collected for this study was obtained through the use of a questionnaire. This restricted the amount and type of information that could be obtained from the target population. Due to this restriction, several variables that may significantly impact the assessment of higher order thinking skills were ignored (e.g., teachers' perception of their students' aptitude or the average socioeconomic status of the students in the classroom).

## CHAPTER 3

## RESULTS

Teacher Questionnaires

For this study, 255 questionnaires (see appendix A) were sent out to teachers in the state of Montana during the fall and early winter of 1998. A total of 145 questionnaires were returned, 35 of which came from teachers who did not meet the criteria of the study. Therefore, from a sample of 220 public high school mathematics teachers in the state of Montana, 110 returned a partially or fully completed questionnaire. Four teachers who returned the questionnaire did not complete question Q-2 and their data could not be used in this study.

Of the 106 teachers who returned a completed questionnaire (meaning that question Q-2 was completed), 5 (approximately 4.7 percent) wrote a Level I problem when asked to write a problem that assessed higher-order thinking skills, 58 (approximately 54.7%) wrote a Level II problem, 33 (approximately 31.1%) wrote a Level III problem, and ten (approximately 9.5%) wrote a Level IV problem. Altogether, almost 60 percent of the teachers wrote a problem that assessed lower-order thinking skills when asked to write a problem that assessed higher-order thinking skills.

When asked to explain why their problem assessed higher-order thinking skills

- thirty-four teachers (approximately 32%) wrote that the problem either focused on the student knowing an algorithm or working through a complicated algorithm (multiple-step process),
- sixteen teachers (approximately 15%) wrote that the problem required the student to analyze or synthesize,
- thirteen teachers (approximately 12%) wrote that the problem required the student to transfer or apply their knowledge,
- thirteen teachers wrote that the problem required the student to use a solution process that varied from the learned algorithm,
- nine teachers (approximately 9%) wrote that the problem required the student to explain or justify their answer or solution,
- eight teachers (approximately 8%) wrote that the problem was real-world or real-life,
- four teachers (approximately 4%) wrote that the problem was open-ended,
- three teachers (approximately 3%) wrote that the problem required the student to recall an idea or process, and
- six teachers (approximately 6%) either did not respond or their response was not similar to any of the others received.

The results of the chi-square tests for null hypotheses 3, 4, 5, 6 and 7 are detailed in Tables 3, 4, 5, 6, and 7, respectively; each followed by the hypothesis and subsequent decision.

Table 3. Chi-square for Categorization of Question vs. Amount of SIMMS Professional Development

	Non-SIMMS or SIMMS Introduced	SIMMS Trained or SIMMS Certified	Total
Level I	4	1	5
Level II	28	31	59
Level III	15	16	31
Level IV	5	5	10
Total	52	53	105

$$\chi^2 = 1.975$$

$$\chi_{0.05,3}^2 = 7.81$$

$$P\text{-value} = 0.578$$

**Null Hypothesis 3:** There is no relationship between the categorization of teachers' written examples of questions that test for higher-order thinking skills and the amount of SIMMS professional development that they have received.

**Decision:** Fail to reject the null hypothesis.

Table 4. Chi-square for Categorization of Question vs. Use of SIMMS IM Curriculum

	Non-SIMMS IM Curriculum	Mixed Curriculum	SIMMS IM Curriculum	Total
Level I or Level II	28	25	11	64
Level III or Level IV	19	14	9	42
Total	47	39	20	106

$$\chi^2 = 0.481$$

$$\chi_{0.05,2}^2 = 5.99$$

$$P\text{-value} = 0.786$$

**Null Hypothesis 4:** There is no relationship between the categorization of teachers' written examples of questions that test for higher-order thinking skills and the use of the SIMMS IM curriculum in their classroom.

**Decision:** Fail to reject the null hypothesis.

Table 5. Chi-square for Categorization of Question vs. Number of Assessment Credit Hours

	0 to 3 Credit Hours	4 to 6 Credit Hours	7 or More Credit Hours	Total
Level I or Level II	35	22	6	63
Level III or Level IV	24	13	6	43
Total	59	35	12	106

$\chi^2 = 0.613$   
 $\chi^2_{0.05,2} = 5.99$   
P - value = 0.736

**Null Hypothesis 5:** There is no relationship between the categorization of teachers' written examples of questions that test for higher-order thinking skills and the number of credit hours that they have accumulated from college classes in assessment or evaluation.

**Decision:** Fail to reject the null hypothesis.

Table 6. Chi-square for Categorization of Question vs. Highest Academic Degree

	Bachelor	Graduate	Total
Level I or Level II	33	31	64
Level III or Level IV	24	18	42
Total	57	49	106

$$\chi^2 = 0.318$$

$$\chi_{0.05,1} = 3.84$$

$$P\text{-value} = 0.573$$

**Null Hypothesis 6:** There is no relationship between the categorization of teachers' written examples of questions that test for higher-order thinking skills and the highest academic degree they have obtained.

**Decision:** Fail to reject the null hypothesis.

Table 7. Chi-square for Categorization of Question vs. Bloom's Educational Objective

	Bloom's Taxonomy						Total
	Level I	Level II	Level III	Level IV	Level V	Level VI	
Level I or Level II	9	7	15	9	3	20	63
Level III or Level IV	4	3	13	5	7	8	40
Total	13	10	28	14	10	28	103

$$\chi^2 = 6.752$$

$$\chi_{0.05,5} = 11.07$$

$$P\text{-value} = 0.240$$

**Null Hypothesis 7:** There is no relationship between the categorization of teachers' written examples of questions that test for higher-order thinking skills and which educational object from Bloom's taxonomy they rank most important in their classroom.

**Decision:** Fail to reject the null hypothesis.

The results of the ANOVA tests for null hypotheses 1 and 2 are detailed in Tables 8 and 9 respectively; each followed by the hypothesis and subsequent decision.

Table 8. ANOVA for Amount of Professional Development

Groups	Count	Sum	Average	Variance			
Level I	5	504	100.8	16211.7			
Level II	58	5721	98.6379	16053.3			
Level III	30	2915	97.1667	32311.5			
Level IV	10	654	65.4	3035.38			
Source of Variation							
Source of Variation	SS	df	MS	F	P-value	F critical	
Between Groups	9837.45	3	3279.15	0.16697	0.91841	2.69647	
Within Groups	1944235	99	19638.7				
Total	1954072	102					

**Null Hypothesis 1:** There is no significant difference between the mean number of hours of professional development for teachers who wrote Level I, Level II, Level III, or Level IV questions as examples of questions that test for higher-order thinking skills.

**Decision:** Fail to reject the null hypothesis.

Table 9. ANOVA for Number of Years Teaching Mathematics

Groups	Count	Sum	Average	Variance		
Level I	5	108	21.6	98.8		
Level II	59	739.75	12.5381	81.4436		
Level III	32	420	13.125	76.6129		
Level IV	10	107	10.7	62.0111		
Source of Variation						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	435.686	3	145.229	1.8397	0.14468	2.69372
Within Groups	8052.03	102	78.9414			
Total	8487.71	105				

**Null Hypothesis 2:** There is no significant difference between the mean number of years teaching mathematics for teachers who wrote Level I, Level II, Level III, or Level IV questions as examples of questions that test for higher-order thinking skills.

**Decision:** Fail to reject the null hypothesis.

### Teacher Interviews

A pilot study, involving three Montana public high school mathematics teachers, was conducted in the fall of 1997. The purpose of this pilot study was to test the methodology used in the qualitative portion of this research. Neither the data nor the conclusions from this pilot study are included in the present research since the selection of the teachers was not random and all of the important results from that pilot study are echoed in this research.

Teacher interviews were conducted over a two-week period during the first part of February, 1999. A stratified sample was taken from the 59 teachers who had indicated on

the return postcard that they would be willing to participate in an interview. There was only one teacher from each category of schools with a substantial Native American student population (see p. 8 for the definition of Substantial Native American Population) who had indicated that he/she would be willing to participate in an interview. The one teacher from a Class A high school with a substantial Native American population decided later not to participate in an interview.

To guarantee anonymity, each teacher was assigned a letter and number (T1 through T10). A brief profile and interview transcript for each teacher can be found in appendix D. Names of cities and individuals have been deleted from the transcripts so that the teachers will remain anonymous. A summary of the data collected from the interviews can be found in Appendix E.

All of the teachers interviewed said that they had been assessed in a traditional manner by their high school teachers. What they meant by traditional is that

- they were assessed using paper and pencil tests,
- many of the problems were computational which involved solving equations and story problems, factoring, and etc.,
- geometry was assessed through two-column proofs, and
- rote memorization was required.

All but three of the teachers said that they had been assessed in a traditional manner by their college teachers. One teacher mentioned that sometimes he was assessed in an innovative manner by his college instructors, however, no explanation was given by the teacher. Another teacher who had obtained a master degree said that assessment at that

level was proof oriented. A third teacher said that when he started taking engineering classes at college, he was assessed at the *Application* level of Bloom's taxonomy.

Six of the teachers interviewed said that their experiences with SIMMS Project or exposure to SIMMS professional development had impacted the way that they assess their students. Two teachers each, said that emphasis on mastering basic skills, reading journal articles, or assessment by their own teachers impacted the way that they assess their students.

Although all of the teachers mentioned using other forms of assessment than tests, quizzes, and homework, nine of the ten teachers weigh tests quite heavily when assigning a letter grade to their students' performance in the classroom. Other forms of assessment used by these teachers included research projects and papers, computer lab work, group work and participation, portfolios and journals, and class presentations.

When asked what levels, according to Bloom's taxonomy, that they assess their students, three said they assess all levels. Three others said that it was determined by the ability of their students, two were not sure, one said that that she did not emphasize the assessment of higher-order thinking skills, and one said that he emphasizes assessment at the level of *Application*. Without access to a representative sample of tests used by each of the teachers, we must be careful in accepting these responses. Marso and Pigge (1992) found that teachers "tend to over-estimate the number of higher order questions used on their tests". (p. 27) It is interesting that three of the teachers said that the levels that they assess their students depends on the ability of the respective students. This assertion

gains support from the study by Raudenbush, Rowan, and Cheong (1993), which will be discussed in the next chapter.

Teachers identified several barriers to the assessment of higher-order thinking skills. They included

- It is difficult to motivate students to learn higher-order thinking skills.
- Assessment of higher-order thinking skills is time-intensive (teachers already have too many students to assess).
- The need to emphasize many basic skills does not leave time to teach higher-order thinking skills.
- Parents pressure teachers to teach basic skills.
- It is time-consuming to write questions that assess higher-order thinking skills.
- Students going on to college must be prepared to pass standardized tests which do not necessarily assess higher-order thinking skills.
- Textbook tests do not assess higher-order thinking skills.

Most of these same barriers were identified by Newmann, Onosko, and Stevenson (1988) when they questioned 25 staff developers on barriers they encountered when working with teachers. The major barriers they encountered were

- teachers' practice, attitudes, and knowledge,
- demands associated with the standard high school curriculum or with assessment procedures, and
- organizational features of high schools.

Four of the six teachers did not send back any tests and one teacher who did send back tests, only sent back two. Originally, it was the intention of the researcher to

examine those tests and categorize each question on all of the tests according to Cooney's taxonomy. Although all of the tests were examined, it was decided to not categorize all of the test questions since half of the teachers did not send back three tests as expected. In addition, since teachers who returned their questionnaires were guaranteed anonymity, it was impossible to make a comparison between the question that they wrote to assess higher-order thinking skills and questions that they used on their classroom tests.

## CHAPTER 4

## SUMMARY, DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

Summary of the Study

The purpose of this study was to determine the levels of questions that Montana public high school mathematics teachers would use in their classroom to assess higher-order thinking skills, isolate factors that relate to the cognitive level of questions that Montana public high school mathematics teachers would use in their classroom to assess higher-order thinking skills, and determine what effect, if any, the SIMMS Project has had upon the levels of the questions that Montana public high school mathematics teachers would use in their classroom to assess higher-order thinking skills.

Questionnaires were sent out to 220 public high school mathematics teachers in the state of Montana during the winter of 1998. A return rate of 50% was obtained which limits the generalization of results from this study to only those teachers involved in the study. A chi-square test of independence was used to determine if there was a relationship between the categorization of the teachers' written examples of a question that tests for higher-order thinking skills and

- the amount of SIMMS professional development that the teachers had received;

- the use of the SIMMS IM curriculum in the teachers' classrooms;
- the number of credit hours that the teachers had accumulated from college classes in assessment or evaluation;
- the highest academic degree obtained by the teachers;
- the educational object from Bloom's taxonomy that the teachers ranked most important for their classroom.

An ANOVA was used to determine if there was a significant difference between

- the mean number of hours of professional development for teachers who wrote Level I, Level II, Level III, or Level IV questions as examples of questions that test for higher-order thinking skills; or
- the mean number of years teaching mathematics for teachers who wrote Level I, Level II, Level III, or Level IV questions as examples of questions that test for higher-order thinking skills.

Telephone interviews were conducted with ten of the teachers who had returned questionnaires, to help interpret the results of this study. Besides providing some background information, teachers were questioned on

- how they were assessed by their teachers in high school and college,
- the factors that most influence the way that they assess their students,
- other assessment methods than classroom tests that they use to assess their students,
- the methods of assessment that provide the most weight when assigning a letter grade to a student's performance in their classroom,

- the feasibility of assessing the higher order thinking skills of their students, and
- the levels of Bloom's taxonomy at which they assess students in their classroom.

### Discussion of the Results

Almost 60% of the teachers who participated in this study wrote a question that assesses lower-order thinking skills when asked to write a question that assesses higher-order thinking skills. Assuming that what gets tested is also what gets taught, the implication is that this same set of teachers probably emphasize lower-order skills in their classroom. This assumption is supported by data collected during the interviews.

Teachers stated that it was difficult to motivate students to learn higher-order thinking skills, that writing and grading items that assess higher-order thinking skills was time-intensive, and that emphasis on basic skills does not leave time to teach higher-order thinking skills.

During the interviews, teachers identified lack of time as a key barrier to assessing higher-order thinking skills. In addition, Marso and Pigge (1992) found that teachers "believe testing, evaluation, and grading activities are among their more demanding and less pleasant classroom responsibilities." (p. 25) In light of this, and considering that two-thirds of the non-responders sampled in this study stated that they did not complete the questionnaire because they did not have time, it would not be surprising if at least

60% of the non-responders in this study would also write a lower-level question to assess higher-order thinking skills.

No significant difference was found between teachers who wrote Level 1, Level 2, Level 3, or Level 4 questions in terms of either the amount of professional development that they had received in the last three years or their years of experience teaching mathematics. Marso and Pigge (1992), in their summary of research on classroom teachers' knowledge and skills related to the development and use of teacher-made tests, concluded that "Neither inservice [sic] training, if provided, nor increased years of teaching experience appear to improve either classroom teacher's testing knowledge or their test construction skills as measured by paper and pencil tests as revealed by direct analysis of construction flaws found on their self-constructed tests." (p.26)

It appears that professional development for public high school teachers in Montana, in the form of workshops, seminars, conferences, college classes, and staff development programs, does not significantly impact teachers' ability to write questions that assess higher-order thinking skills. This conjecture is supported by the finding, stated above, that there was no significant difference attributed to the years of experience teaching mathematics. It would be expected that the longer a teacher is teaching, the more professional development he/she would receive since recertification requirements obligate teachers to routinely participate in accredited professional development activities. This accumulation of professional development hours, over several years, does not appear to have a significant impact on the ability of teachers to write questions that

assess higher-order thinking skills. This may be attributed to what subjects are taught in professional development courses and how they are taught.

Cooney (1992) found that "less experienced teachers were less likely to generate Level 3 or 4 items than their more experienced counterparts." (p. 9) A summary of the ANOVA test in Table 9, on page 55, suggests an opposite trend. There is almost an inverse relationship between the level of question that the teachers wrote and their average years of experience teaching mathematics. None of the conjectures for explaining this trend can be supported by data from this study or from other research that was examined during this study; therefore they will not be stated.

The interviews provide no information with regards to the impact of professional development or years of experience teaching mathematics on teachers' ability to write questions that assess higher-order thinking skills. Instead, the interviews highlight the fact that some of the more experienced teachers have developed more efficient means of assessing their students. For example, teacher T5, who has taught for 28 years, does not collect homework. Instead, he walks around the classroom, helping and observing students while they complete their homework. He does spend a considerable amount of time correcting and writing comments on his students' tests. Teacher T8, who has 22 years of teaching experience, provides her students with sample problems which they work through and then bring up to her desk for correction when they have finished. This allows her to quickly assess their work and provides the students with immediate feedback. Teaching experience and exposure to other methods of assessment may help

teachers assess their students in a more efficient manner, but may not necessarily change their beliefs or practices with respect to the assessment of higher-order thinking skills.

No significant relationship was found between the amount of SIMMS professional development that teachers had received and the levels of questions that they would write to assess higher-order thinking skills. Fielding and Shaughnessy (1990) developed a professional development program to enhance high school science teachers' skills in designing and using tests as aids to instruction. They found that their own program, although rated high by participating teachers, had no lasting impact. Their rationale for this may apply to the results of the present study. Fielding and Shaughnessy identified the following barriers:

- demands of classroom management,
- the curriculum's overemphasis on content coverage, and
- lack of organizational [school administration] commitment.

It appears that SIMMS professional development has had little impact on teachers in this study with regards to writing questions that assess higher-order thinking skills.

No significant relationship was found between teachers' use of the SIMMS IM curriculum and the levels of questions that they would use in their classroom to assess higher-order thinking skills. This is all the more surprising in light of the fact that teachers who use the SIMMS IM curriculum are provided with questions that assess higher-order thinking skills. What must be questioned then is how often teachers actually assign those problems to their students. Conclusions from the study by Marso and Pigge (1992) may help answer this question. They found that

- Teachers believe that self-constructed assessments generally better meet the instructional needs of their classes than do assessments derived from other sources such as workbooks or textbooks.
- Teachers believe that essay tests as compared to objective tests are impractical and disliked by pupils but result in greater study efforts and usually measure at higher cognitive levels. (pp. 23-24)

During the interviews, six of the ten teachers stated that either SIMMS professional development or the SIMMS IM curriculum had influenced the way that they assessed their students. Normally, there was no follow-up question on how SIMMS professional development or the SIMMS IM curriculum influenced their assessment practices since there was concern by the researcher that teachers not perceive this as a study for or by the SIMMS Project; therefore biasing the information received. Two teachers did offer a partial explanation. Teacher T3 said that the SIMMS IM curriculum complemented discovery learning, which at one time was emphasized at her school. Like the discovery learning, SIMMS integrated mathematics is a student centered, hands-on curriculum. Teacher T6 said that SIMMS professional development had changed her teaching strategies. She did not explain how her teaching strategies changed under the influence of SIMMS professional development. It may be that SIMMS professional development and the SIMMS IM curriculum has had a greater impact on how teachers teach rather than how they assess.

No significant relationship was found between the number of credit hours that teachers had accumulated in assessment and evaluation and the levels of questions that they would write to assess higher-order thinking skills. An observation by Newman and Stallings (1982) best summarizes the implication of this finding. They state that "Simply

requiring more of the traditional type of [measurement] coursework has not solved the problem of inadequate measurement preparation.” (p. 8) Furthermore, Marso and Pigge (1992) found that “Teachers believe that preservice [sic] training in tests and measurement provides them with adequate background concepts and principles but insufficiently prepares them for the successful integration of pupil assessment and instruction.” (p. 24) This leads to the conjecture that Montana high school mathematics teachers may possibly receive adequate instruction in the concepts related to testing, but not enough hands-on experience, with respect to mathematical assessment, that can be applied in the classroom environment.

No significant relationship was found between the highest academic degree obtained by teachers and the levels of questions that they would write to assess higher-order thinking skills. Raudenbush, Rowan, and Cheong (1993) concluded that the results of their study “provide little reason to believe that formulas like providing more preservice [sic] teacher education ... are by themselves likely to raise the conceptual level of discourse in the secondary math and science classes we studied.” (pp. 548-549) With respect to writing questions that assess higher-order thinking skills, it would seem that what is taught, practiced (by the students), and assessed in college classes, rather than the amount of instruction received, would influence what teachers assess. Continuing this conjecture, it may be that graduate courses in mathematics or mathematics education do not adequately embed instruction and practice that focus on writing assessment items that address higher-order thinking skills.

Research conducted by Raudenbush, Rowan, and Cheong (1993) concluded that the typical secondary mathematics teacher "sets higher-order objectives for courses taken later in a prescribed sequence." (p. 548) These later courses (e.g. calculus) are usually taken by students who are normally described by their teachers as having high aptitude. It would not be surprising if teachers who teach higher-level mathematics courses (e.g., honors courses or calculus) in high school also set higher-order objectives for their students and assess higher-order thinking skills. This conjecture is strengthened by the observation that three of the teachers interviewed for this study stated that the levels at which they assess (according to Bloom's taxonomy) their students were determined by the ability of their students. Furthermore, three other teachers said that they assess all levels of Bloom's taxonomy; but it came out during the interview that the assessment of higher-order thinking skills was reserved mainly for the students in their higher-level courses. Contrary to those observations, no significant relationship was found between the educational objectives that teachers ranked most important in their classroom and the levels of questions that they would use in their classroom to assess higher-order thinking skills.

The discrepancy discussed above may be explained by comments that teachers made on their questionnaires with respect to ranking Bloom's educational objectives. One teacher found the objectives vague while two others stated that they had difficulty ranking them. Two teachers ranked *Recall* first since their students needed that skill before they obtained the others. Another teacher said that *Recall* came first, but did not rank it first. Two teachers emphasized the word *should* in the question meaning that they

ranked the objectives according to what they should be doing rather than what they actually were doing in their classroom. Other teachers may not have realized this difference. Wording of the instructions for this problem and the complexity of the task may have resulted in finding no significant relationship.

### Conclusions

The results of this study lead us to suspect that in over half of the public high school mathematics classes in the state of Montana, we would find teachers who believe that lower level questions and problems actually assess higher-order thinking skills. This would most likely influence the way that they teach and assess their students.

Furthermore, those activities that we would assume were developed to improve teachers' performance in the classroom, do not seem to induce teachers to assess higher-order thinking skills. Specifically, professional development, college measurement courses, and continuing education do not seem to impact teachers' assessment of higher-order thinking skills; furthermore, we cannot assume that teaching experience alone, without proper training and classroom support, will improve this situation. If professional development, college measurement courses, and continuing education are not impacting teachers assessment of higher-order thinking skills, then perhaps these activities should incorporate hands-on experiences for teachers to write questions that assess higher-order thinking skills.

There is indirect evidence that the goals teachers set for their students may impact the levels at which they assess their students. This study did not find evidence to support

this conclusion, but that may have been due to a problem with the question used to gather that data.

Use, by teachers in this study, of the SIMMS IM curriculum was not found to significantly influence the questions that they would use to assess higher-order thinking skills in their classrooms, even though such assessment items are provided with the curriculum. It does not seem sufficient to only provide teachers with questions that assess higher-order thinking skills. They must also become comfortable with and confident in using those items in their classroom.

### Recommendations

#### Recommendations for Future Research

Several of the studies on the assessment of higher-order thinking skills, discussed in the literature review, utilized a methodology for categorizing test questions, based upon Bloom's taxonomy. Except for Stiggins, Griswold, and Wikelund (1989), none of those researchers published the rubric that they used along with their research. The problem with this is that we have no way of determining if all of these rubrics are consistent. This leaves in doubt a definitive conclusion that teacher-generated tests, generally, do not assess higher-order thinking skills. Therefore, it is recommended that a detailed rubric be developed and published for use in categorizing mathematical problems. A model for this could be the one developed by the Dutch educators Pierre and Dina van Hiele-Geldorf (normally referred to as the van Hiele model) in the late 1950's, that categorizes geometric thinking.

It is suggested that further research be conducted on how to improve the Total Design Method, outlined by Dillman (1978), to take into consideration teachers' busy schedule during the school year. It may be that research should be conducted during the summer months rather than during the school year, although this has the disadvantage that teachers may not accurately recall specific assessment practices that occur during the school year. In addition, there may be a format for the questionnaire that will help guarantee a larger return rate.

There have been a number of studies conducted over the past 25 years that have concluded that, generally speaking, many teacher-made tests do not assess higher-order thinking skills. It is now time to research factors that either contribute to or ameliorate this problem. One such factor that requires further research is the goals set by teachers in relation to their perception of their students' aptitude. In other words, do teachers who believe that they are teaching high-ability students also write tests with a higher percentage of questions that assess higher-order thinking skills than do teachers who believe that they are teaching low-ability students?

Another approach to the problem may be to identify teachers who write tests that assess both lower and higher-order thinking skills in a balanced proportion and find out what environmental and/or personal factors are common to those teachers.

Other questions that need further examination are as follows:

- How do college measurement courses relate to actual assessment in high school mathematics classrooms?

- How much does the assessment of higher-order thinking get emphasized in teacher professional development or graduate studies related to teaching?
- What does Change Theory have to tell us about changing teachers assessment practices with respect to the assessment of higher-order thinking skills?
- How does teaching relate to assessment with respect to higher-order thinking skills?

### Recommendations on Methodology

Questionnaires are an efficient method for gathering data from a large population. One of the biggest problems with this methodology is low return rate. Two key points must be remembered when designing a questionnaire for teachers. Teachers are very busy and a certain percentage of that population is mobile. A few modifications to the original questionnaire used for this study may have resulted in a higher return rate. For example,

- questions Q-3 and Q-8 could have been eliminated without impacting the results this study;
- question Q-7 should have asked teachers to choose the most important objective from the list rather than rank the objectives, and should have referred to these as *outcome* objectives; and
- question Q-2 could have been designed so that teachers would be asked to indicate which questions, from a small list of questions, assess higher-order thinking skills.

When conducting a pilot study for research that uses questionnaire, teachers should be interviewed as soon as possible after completing the questionnaire. They should be asked to comment on their understanding of what each question is asking and indicate which questions they found vague or confusing. Before choosing a sample of teachers for a study, the actual population should be confirmed. For the present research, it was found that almost one-third of the questionnaires that were not returned may have been sent to teachers who had moved or were not eligible for participation in this study. Confirming the eligibility of teachers for inclusion in the population for the study may require finding a second source of information about the teacher population in question.

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APPENDICES

APPENDIX A  
QUESTIONNAIRE AND CORRESPONDENCE

**Mathematical Assessment in the Public High Schools:  
A Study of Factors that Affect the Writing of Test Questions**



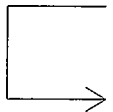
**Research supported by the Department of Mathematics at  
Montana State University, Bozeman**

This questionnaire has been designed to obtain information using only a small number of carefully constructed questions. Therefore, it is important that you answer each question as thoroughly and accurately as possible.

To complete this questionnaire you will be asked to write two test questions, provide information on the professional development activities in which you have participated, list the curriculum materials you presently use in your classroom, and answer questions about your educational philosophy and background.

Q-1 Do you currently teach mathematics in a public high school (grades 9-12) in the state of Montana? (Circle one of the numbers.)

- 1 YES
- 2 NO



(If NO) Inasmuch as the focus of our research is upon teachers of mathematics in public high schools in the state of Montana, it is not necessary for you to answer the remainder of the questions. However, we ask that you **please return the questionnaire and postage-free postcard** so that we do not inconvenience you by sending a replacement questionnaire in the near future. Thank you for your cooperation.

If you answered YES to question Q-1, please continue on the next page.

Q-2a In the space below write a typical problem (with or without drawings) that you would give your students to test for **higher order thinking skills**. Please write your problem for a **specific** class (one that you currently teach), unit in your curriculum, and concept or range of concepts.

Q-2b On the lines below, write the name of the class, the unit in the class for which the question would be used, and the concept(s) being tested.

CLASS: \_\_\_\_\_

UNIT: \_\_\_\_\_

CONCEPT(S): \_\_\_\_\_

Q-2c Please explain why you believe that the question you wrote above tests for **higher order thinking skills**.

Q-3a In the space below write a typical problem (with or without drawings) that you would give your students to test for **lower order thinking skills**. Please write this problem for the same **specific** class, unit in your curriculum, and concept or range of concepts as you did in question Q-2a.

Q-3b Please explain why you believe that the question you wrote above tests for **lower order thinking skills**.

Questions four and five focus on professional development (continuing education) activities in which you have participated that **pertain to mathematics education**. These activities would include seminars, workshops, conferences, post-baccalaureate college classes, and staff development programs. Do not include undergraduate courses that you took to get your teaching certification. **If you include post-baccalaureate college classes, please list only the number of hours spent in the classroom, not credit hours.** Professional development activities may be related to assessment, evaluation, the use or development of curriculum, technology, research, methods of instruction, classroom management, or students with special needs.

- Q-4 Approximately how many hours of professional development, directly related to mathematics education, have you received in the last three years (1996-1998)? (Write a number in the space below.)

\_\_\_\_\_ HOURS

- Q-5 Please place a check beside the name(s) of the systemic curriculum project(s) below for which you have received professional development in the last seven years (1992-1998). Also, indicate the approximate number of hours that you participated in professional development activities related to the systemic curriculum project(s) that you checked.

CURRICULUM PROJECT	HOURS PROFESSIONAL DEVELOPMENT
_____ SIMMS*	_____ HOURS
_____ STEP*	_____ HOURS
_____ STEM*	_____ HOURS
_____ OTHER (Please specify on the lines below.)	_____ HOURS
_____	
_____	

- \* SIMMS (Systemic Initiative for Montana Mathematics and Science Project)  
 STEP (Systemic Teacher Excellence in Preparation Project)  
 STEM (Six Through Eight Mathematics Project)

- Q-6 On the lines below write out the names of the mathematics classes that you currently teach (1998-1999 school year), the titles of the textbooks that you use in those classes, and the publishers of those textbooks. If you teach the same class two or more times during the day, include it only once below. If you do not use a textbook, please explain what curriculum materials you do use and where you obtained them, on the line "Other".

CLASS 1 COURSE TITLE: \_\_\_\_\_  
TEXTBOOK TITLE: \_\_\_\_\_  
TEXTBOOK PUBLISHER: \_\_\_\_\_  
OTHER: \_\_\_\_\_  
\_\_\_\_\_

CLASS 2 COURSE TITLE: \_\_\_\_\_  
TEXTBOOK TITLE: \_\_\_\_\_  
TEXTBOOK PUBLISHER: \_\_\_\_\_  
OTHER: \_\_\_\_\_  
\_\_\_\_\_

CLASS 3 COURSE TITLE: \_\_\_\_\_  
TEXTBOOK TITLE: \_\_\_\_\_  
TEXTBOOK PUBLISHER: \_\_\_\_\_  
OTHER: \_\_\_\_\_  
\_\_\_\_\_

CLASS 4 COURSE TITLE: \_\_\_\_\_  
TEXTBOOK TITLE: \_\_\_\_\_  
TEXTBOOK PUBLISHER: \_\_\_\_\_  
OTHER: \_\_\_\_\_  
\_\_\_\_\_

CLASS 5 COURSE TITLE: \_\_\_\_\_  
TEXTBOOK TITLE: \_\_\_\_\_  
TEXTBOOK PUBLISHER: \_\_\_\_\_  
OTHER: \_\_\_\_\_  
\_\_\_\_\_

CLASS 6 COURSE TITLE: \_\_\_\_\_  
TEXTBOOK TITLE: \_\_\_\_\_  
TEXTBOOK PUBLISHER: \_\_\_\_\_  
OTHER: \_\_\_\_\_  
\_\_\_\_\_

- Q-7 Several educational objectives have been listed below. Rank-order them by placing a number (1-6) in front of each objective, where **1 indicates "Most Important"** and **6 indicates "Least Important"**. Please do not place the same number in front of more than one objective.

STUDENTS SHOULD BE ABLE TO:

- \_\_\_\_\_ BREAK DOWN DIAGRAMS, OPERATIONS, PROPOSITIONS, ALGORITHMS, OR CONCEPTS INTO THEIR MATHEMATICAL COMPONENTS SO AS TO ESTABLISH THE INTERRELATIONSHIP OF THESE PARTS.
- \_\_\_\_\_ APPLY FAMILIAR MATHEMATICAL OPERATIONS, PROPOSITIONS, ALGORITHMS, OR CONCEPTS TO NEW SITUATIONS.
- \_\_\_\_\_ COMBINE KNOWLEDGE OF MATHEMATICAL OPERATIONS, PROPOSITIONS, ALGORITHMS, OR CONCEPTS SO AS TO IDENTIFY CONNECTIONS AND COMPREHEND UNDERLYING PATTERNS.
- \_\_\_\_\_ RECALL MATHEMATICAL FACTS, OPERATIONS, OR ALGORITHMS.
- \_\_\_\_\_ ASSESS OR EVALUATE THE UTILITY OF MATHEMATICAL OPERATIONS, PROPOSITIONS, ALGORITHMS, OR CONCEPTS SO AS TO MAKE INFORMED DECISIONS.
- \_\_\_\_\_ ACCURATELY TRANSLATE FROM ONE MATHEMATICAL REPRESENTATION DIRECTLY TO ANOTHER MATHEMATICAL REPRESENTATION.

- Q-8 How many years of **teaching experience** do you have as of July, 1998? (Write a number in the space below.)

\_\_\_\_\_ YEARS

- Q-9 How many years of experience do you have **teaching mathematics in a public high school** as of July, 1998? (Write a number in the space below.)

\_\_\_\_\_ YEARS

- Q-10 Circle the grade(s) in high school that you currently teach.

9      10      11      12

Q-11 What is the **highest** academic degree that you obtained? (Check one of the options.)

- BACHELOR  
 MASTER  
 DOCTOR  
 OTHER (Please explain.) \_\_\_\_\_  
\_\_\_\_\_

Q-12 For which subject area did you receive the degree indicated in question Q-11? (Check one of the options.)

- MATHEMATICS  
 MATHEMATICS EDUCATION  
 OTHER (Please specify.) \_\_\_\_\_

Q-13 How many **credit hours** have you accumulated from classes in assessment or evaluation at the college level (graduate or undergraduate)? (Check one of the options.)

- 0-3 SEMESTER CREDIT HOURS  
(i.e. 0-4 QUARTER HOURS)  
 4-6 SEMESTER CREDIT HOURS  
(i.e. 5-9 QUARTER HOURS)  
 7 OR MORE SEMESTER CREDIT HOURS  
(i.e. 10 OR MORE QUARTER HOURS)

Thank you for your time and effort. Your contribution to this research is greatly appreciated. If you have any comments or suggestions concerning this research please use the space on the following page for that purpose.

COMMENTS OR SUGGESTIONS

## INITIAL POSTCARD

Dear Mathematics Teacher,

A doctoral student under my direction is conducting a research study for both the Mathematics and Education departments at Montana State University-Bozeman.

In one week you will be mailed a questionnaire. The information obtained from this questionnaire will be used to help redesign methods courses and professional development programs at MSU-Bozeman. We hope, thereby, to better meet the needs of mathematics teachers such as yourself.

We understand how busy teachers are and for that reason, we have involved nearly 20 Montana high school teachers in the design and format of the questionnaire. With their assistance, we have reduced its length so that it can be completed in 30 to 40 minutes. Please assist us in this research by completing the questionnaire.

Thank you,

Maurice Burke, Associate Professor

## INITIAL COVER LETTER

Dear Mathematics Teacher,

Assessment is considered by many mathematics educators to be the driving force behind curriculum development and implementation. Unfortunately, there is very little systemic research available on this issue. Therefore, as a doctoral candidate, under the direction of members of the faculty at Montana State University-Bozeman (MSU- Bozeman), I am conducting research whose purpose is to gather information on questions that high school mathematics teachers use to assess their students and factors that may influence the type of questions that they ask. The results of this research will be made available to mathematics educators at all of the universities in the state of Montana. This information will be used to help redesign methods courses and professional development programs at MSU-Bozeman so as to better meet the needs of mathematics teachers such as yourself.

You are among a group of randomly selected high school mathematics teachers being asked to contribute to this research. As a professional in your field you can provide us with invaluable information that is not available from any other source. Your contribution is critical. It is important that each questionnaire be completed and returned so as to obtain an accurate representation of all of the secondary mathematics teachers in the state.

You are assured of complete anonymity since your name cannot be associated with the questionnaire that you return. A secretary will collect and combine all of the returned questionnaires into one stack and deliver them to the researchers. We therefore ask that when you have completed the questionnaire, you print your name on the enclosed postage-free postcard and mail it back separately so that we can remove your name from our mailing list. Only the questionnaire should be returned in the postage-free envelope.

Our pilot study has shown that it takes at most 30 to 40 minutes to complete the questionnaire. You may receive a summary of the results of this research by circling YES on the postcard. These results will not be available until late spring or early summer of 1999. I would be happy to answer any questions you might have. Please write or call.

Thank you for your assistance,

David Harpster  
Director of Research  
Home: (406) 585-3407

Dr. Maurice Burke  
Associate Professor  
Office: (406)994-5344

Dr. Leroy Casagrande  
Associate Professor  
Office: (406)994-5953

## FOLLOW-UP POSTCARD

Dear Mathematics Teacher,

Last week a questionnaire was sent to you to obtain information about your assessment practices and factors that may influence those practices. Your name was drawn in a random sample of secondary mathematics teachers in the state of Montana.

If you have already completed and returned the questionnaire please accept our sincere thanks. If not, I encourage you to do so today. Because the questionnaire was sent only to a representative sample of secondary mathematics teachers in the state, it is important that you complete and return it so that your thoughts and ideas are represented in this research.

If by some chance you did not receive a questionnaire, or it was misplaced, please contact me by e-mail at

[harpster@mathfs.math.montana.edu](mailto:harpster@mathfs.math.montana.edu)

or call and leave a message at the main office of the Mathematics Department at Montana State University. The number is (406) 994-3603. Please call between the hours of 8:30 to 11:30 A.M. and 1:30 to 4:30 P.M., Monday through Friday.

Sincerely,

David Harpster  
Director of Research

## FIRST FOLLOW-UP LETTER

(Date)

Dear (teacher's first name),

Three weeks ago a questionnaire was mailed to you requesting information about your assessment practices and factors that may influence them. Our records indicate that we have not yet received your completed questionnaire.

This research was undertaken to help redesign methods courses and professional development programs at MSU-Bozeman and therefore benefit the mathematics teaching profession in Montana.

We are writing to you again because of the significance that each completed questionnaire has to the usefulness of this study. Your name was drawn from a list of all Montana high school mathematics teachers. For this survey to be truly representative, we need your input. Your thoughts and ideas are important to us.

I encourage you to respond as soon as possible. In the event that your questionnaire was misplaced, a replacement is enclosed. If you have already mailed your questionnaire, please return the enclosed postage-paid postcard so that we can remove you from our mailing list. For your convenience, you may contact us by e-mail. The address is:

[harpster@mathfs.math.montana.edu](mailto:harpster@mathfs.math.montana.edu)

Your cooperation is greatly appreciated.

David Harpster  
Director of Research  
Home: (406) 585-3407

Dr. Maurice Burke  
Associate Professor  
Office: (406)994-5344

## SECOND FOLLOW-UP LETTER.

(Date)

Dear (teacher's first name),

I am writing to you about our study of the assessment practices of secondary mathematics teachers in the state of Montana. We have not yet received your completed questionnaire. The large number of returned questionnaires (107) is encouraging. However, for this state-wide study to be valid we need at least 43 more high school mathematics teachers to respond.

The data that we receive from this study will be use by mathematics educators at MSU-Bozeman to better design methods courses and professional development programs that will benefit all secondary mathematics teachers in the state. To provide for the needs of as many teachers as possible we encourage every person who was sent a questionnaire to respond. I urge you to complete and return the questionnaire as soon as possible so that we may begin analysis of all of the data.

This if the last letter you will receive. Your contribution to the success of this study will be greatly appreciated.

David Harpster  
Director of Research  
Home: (406) 585-3407

Dr. Maurice Burke  
Associate Professor  
Office: (406)994-5344

## NON-RESPONDER COVER LETTER

(Date)

Dear (teacher's first name),

We would first like to thank you for agreeing to take the time to fill out this questionnaire. Through interviews with several teachers around the state we have, not surprisingly, found that non-responders are generally conscientious teachers like yourself who have a very heavy workload. We therefore understand the imposition we are making on your time and will take this into consideration for future research.

We would like to finish our data collection as soon as possible so that we can begin to analyze the data. We therefore ask that, if all possible, you mail your finished questionnaire by February 8. We will receive about 20 of these stamped questionnaires and there is no way we can differentiate between them. We therefore ask that you return the postage-free postcard separately so that we can remove your name from our list. Since we have already selected 10 teachers to interview, you need only indicate on the postcard whether or not you would like to receive a summary of the results of this research.

Thank you again for your cooperation and know that we sincerely appreciate your help in this study.

David Harpster  
Director of Research  
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APPENDIX B  
CATEGORIZATION RUBRIC FOR TEACHER-MADE QUESTIONS

### Bloom/Cooney Rubric

To determine the level of a question, the teacher's intent for the problem and possible student interpretations must be taken into consideration.

**Level 1 - Simple computation or recognition.**

Knowledge - **Recognize or recall** mathematical facts, operations, formulas, theorems or algorithms.

- add, subtract, multiply, divide, exponent, root (simple computations)
- determine order of operations
- recognize or recall properties (commutative, associative, distributive, groups, rings, and etc.)
- recognize or recall math symbols, vocabulary, or terminology
- measure length
- recall or recognize formulas for area or volume of basic geometric shapes
- recall and/or recite formulas or theorems
- construct simple tables, charts, or graphs
- classify simple geometric shapes; identify pertinent characteristics of a mathematical object
- read information from charts, graphs, or tables

**Level 2 - Comprehension.** Student must make some decision but once made the solution process is straightforward, e.g., a simple one-step problem.

Comprehension - Accurately **translate** from one mathematical representation directly to another mathematical representation.

- interpret, interpolate, or extrapolate from tables, charts, or graphs
- plot simple curves to scatter plots
- restate formulas or theorems in your own words
- write equivalent equations or formulas
- sketch a graph or write an equation to represent a given relationship
- set-up and solve a "direct" or "template" mathematical problem
- solve a multiple-step problem that does not require transfer
- explain a specific concept or process to another person who is unfamiliar with the concept or process
- compare and contrast two or more "things"
- identify a simple pattern
- work through a learned mathematical process
- interpret an answer
- create a specified template mathematical model where the data fits the model exactly (a line given 2 points, a parabola given 3 points, an exponential function given 2 points, and etc.)

**Level 3** - An application or multiple-step problem in which the student must make several

decisions about the solution process or what operations to use.

Application - Apply familiar mathematical operations, properties, algorithms, or concepts to new situations without making assumptions beyond those provided in the problem.

- set-up and solve “indirect” or “non-template” mathematical problems
- solve a multiple-step problem that requires transfer
- write a “direct” or “template” proof
- **transfer** knowledge of a known problem to an unknown , but related, problem
- provide an example (assuming the example has not been previously discussed in class in the context being assessed) for a mathematical argument or describe an application for a given mathematical model
- graph a relationship where the relationship must first be constructed
- an informal proof that cannot be generalized
- create (without technology) a specified type of model from data that does not exactly fit the model

**Level 4 - Non-routine or open-ended problem.**

Analysis - Break down diagrams, operations, propositions, algorithms, or concepts into their mathematical components so as to **identify and explain underlying patterns** (generalization is important here).

- recognize the need for and make reasonable unstated assumptions with regards to an open-ended problem
- recognize and utilize relevant information in a real-world problem
- take into consideration all hypotheses when applying a theorem and explain or demonstrate the consequences of leaving out one or more hypotheses
- identify relationships and recognize how changes in one or more components affect changes in other components

Synthesis - Combine knowledge of mathematical operations, propositions, algorithms, or concepts so as to **identify and communicate connections**.

- thoroughly explain a general mathematical concept or process to another person unfamiliar with the concept or process
- create (without assistance) an appropriate mathematical model (non-template)
- identify a general relationship, represent the relationship mathematically, and communicate that relationship using generally accepted mathematical writing techniques
- categorize an unfamiliar mathematical object utilizing a set of definitions
- write a rigorous proof
- independently design a set of criteria to differentiate and classify mathematical objects that can be used by others
- alter an existing set of criteria, for differentiating and classifying mathematical objects, for application to a unique situation
- solve a problem that:
  1. requires the application of knowledge from more than one area of mathematics and
  2. requires connections be made between different areas of mathematics

Evaluation - **Assess or evaluate** the utility of mathematical operations, properties, algorithms, or concepts so as to make informed decisions.

- determine the best mathematical model for a given scenario
- solve an open-ended problem, providing a rational explanation for each step in the process
- accurately assess the work of another student according to a given set of criteria
- accurately assess your own work according to a given set of criteria (metacognition)

Open-ended Question: A question that: (1) is non-algorithmic; (2) is complex; (3) may yield more than one solution, each of which has different benefits and/or disadvantages; (4) may require nuanced judgments – sensitivity to subtle aspects of a problem situation; (5) may involve the application of multiple and sometimes conflicting criteria; (6) may involve uncertainty because all of the facts are not known; (7) may involve self-regulation of the thinking process (metacognition); (8) may require one to find structure in apparent disorder; and (9) requires effort because of the complexity of problems. (Frederiksen, 1994, p. 538)

APPENDIX C  
DATA FROM THE QUESTIONNAIRES

Teacher Number	Question Number							
	Q-2	Q-4	Q-5	Q-6	Q-7	Q-9	Q-11	Q-13
1	4	50 hrs.	SIMMS Trained	SIMMS	6	4 yrs.	Bachelor	4 to 6 hrs.
2	2	54 hrs.	SIMMS Trained	Mixed	1	3 yrs.	Bachelor	0 to 3 hrs.
3	2	100 hrs.	Non- SIMMS	Non- SIMMS	6	2 yrs.	Bachelor	4 to 6 hrs.
4	3	5 hrs.	SIMMS Intro.	Non- SIMMS	4	17 yrs.	Bachelor	4 to 6 hrs.
5	3	1000 hrs.	SIMMS Cert.	Mixed	5	11 yrs.	Bachelor	7 or more hrs.
6	2	40 hrs.	Non- SIMMS	Non- SIMMS	2	4 yrs.	Master	4 to 6 hrs.
7	2	2	Non- SIMMS	Non- SIMMS	4	24 yrs.	Bachelor	0 to 3 hrs.
8	1	321 hrs.	SIMMS Cert.	SIMMS	2	31 yrs.	Master	4 to 6 hrs.
9	2	65 hrs.	SIMMS Trained	Mixed	6	5 yrs.	Bachelor	4 to 6 hrs.
10	2	64 hrs.	SIMMS Intro.	Non- SIMMS	1	1 yr.	Master	0 to 3 hrs.
11	2	3 hrs.	Non- SIMMS	Non- SIMMS	3	25 yrs.	Bachelor	0 to 3 hrs.
12	N/A	8 hrs.	Non- SIMMS	Non- SIMMS	3	8 yrs.	Bachelor	7 or more hrs.
13	2	N/A	Non- SIMMS	Non- SIMMS	6	3 yrs.	Bachelor	0 to 3 hrs.
14	3	200 hrs.	SIMMS Cert.	SIMMS	5	21 yrs.	Master	4 to 6 hrs.
15	2	200 hrs.	SIMMS Cert.	Mixed	4	12 yrs.	Master	7 or more hrs.
16	3	45 hrs.	SIMMS Trained	Mixed	1	2 yrs.	Bachelor	4 to 6 hrs.
17	3	0 hrs.	Non- SIMMS	Non- SIMMS	4	1.5 yrs.	Bachelor	0 to 3 hrs.
18	3	15 hrs.	Non- SIMMS	Non- SIMMS	6	2 yrs.	Bachelor	4 to 6 hrs.

Teacher Number	Question Number							
	Q-2	Q-4	Q-5	Q-6	Q-7	Q-9	Q-11	Q-13
19	2	35 hrs.	SIMMS Trained	Mixed	3	22 yrs.	Master	4 to 6 hrs.
20	2	10 hrs.	SIMMS Intro.	Mixed	2	2 yrs.	Bachelor	4 to 6 hrs.
21	4	55 hrs.	SIMMS Intro.	Non- SIMMS	5	4 yrs.	Bachelor	0 to 3 hrs.
22	2	15 hrs.	SIMMS Trained	Mixed	3	17 yrs.	Master	4 to 6 hrs.
23	N/A	14 hrs.	Non- SIMMS	Non- SIMMS	1	12 yrs.	Bachelor	0 to 3 hrs.
24	2	220 hrs.	SIMMS Cert.	SIMMS	6	9 yrs.	Master	7 or more hrs.
25	2	70 hrs.	SIMMS Intro.	Non- SIMMS	1	24.25 yrs.	Master	0 to 3 hrs.
26	2	12 hrs.	SIMMS Cert.	Mixed	6	7 yrs.	Master	0 to 3 hrs.
27	2	20 hrs.	SIMMS Trained	Mixed	1	5 yrs.	Master	0 to 3 hrs.
28	3	75 hrs.	SIMMS Trained	Mixed	5	22 yrs.	Master	0 to 3 hrs.
29	2	40 hrs.	Non- SIMMS	Non- SIMMS	6	6 yrs.	Master	4 to 6 hrs.
30	4	30 hrs.	SIMMS Cert.	SIMMS	5	24 yrs.	Master	7 or more hrs.
31	2	500 hrs.	SIMMS Cert.	Mixed	2	15 yrs.	Master	7 or more hrs.
32	1	30 hrs.	SIMMS Intro.	Mixed	2	26 yrs.	Master	0 to 3 hrs.
33	2	30 hrs.	SIMMS Cert.	Mixed	4	25 yrs.	Master	0 to 3 hrs.
34	2	70 hrs.	Non- SIMMS	Non- SIMMS	4	15 yrs.	Master	0 to 3 hrs.
35	2	0 hrs.	Non- SIMMS	Mixed	5	.5 yrs	Bachelor	0 to 3 hrs.
36	1	3 hrs.	SIMMS Intro.	Non- SIMMS	1	5 yrs.	Master	0 to 3 hrs.

## Question Number

Teacher Number	Q-2	Q-4	Q-5	Q-6	Q-7	Q-9	Q-11	Q-13
37	3	60 hrs.	SIMMS Cert.	SIMMS	3	24 yrs.	Bachelor	4 to 6 hrs.
38	3	120 hrs.	Non- SIMMS	Non- SIMMS	3	4 yrs.	Bachelor	4 to 6 hrs.
39	2	30 hrs.	SIMMS Intro.	Mixed	3	5 yrs.	Bachelor	4 to 6 hrs.
40	1	60 hrs.	SIMMS Intro.	Non- SIMMS	3	21 yrs.	Master	0 to 3 hrs.
41	N/A	0 hrs.	SIMMS Trained	Mixed	4	10 yrs.	Bachelor	0 to 3 hrs.
42	2	100 hrs.	SIMMS Cert.	Mixed	3	27 yrs.	Master	0 to 3 hrs.
43	3	20 hrs.	SIMMS Intro.	Non- SIMMS	3	10 yrs.	Bachelor	0 to 3 hrs.
44	3	160 hrs.	SIMMS Trained	SIMMS	5	30 yrs.	Master	4 to 6 hrs.
45	4	30 hrs.	Non- SIMMS	Non- SIMMS	1	17 yrs.	Bachelor	4 to 6 hrs.
46	2	12 hrs.	Non- SIMMS	Non- SIMMS	6	1 yr.	Bachelor	0 to 3 hrs.
47	3	20 hrs.	SIMMS Cert.	Mixed	3	11 yrs.	Master	0 to 3 hrs.
48	3	5 hrs.	Non- SIMMS	Non- SIMMS	3	16 yrs.	Master	0 to 3 hrs.
49	2	100 hrs.	Non- SIMMS	Non- SIMMS	6	8 yrs.	Bachelor	0 to 3 hrs.
50	3	20 hrs.	SIMMS Cert.	Mixed	2	25 yrs.	Master	0 to 3 hrs.
51	3	40 hrs.	SIMMS Cert.	SIMMS	3	12 yrs.	Master	0 to 3 hrs.
52	2	600 hrs.	SIMMS Cert.	SIMMS	6	16 yrs.	Master	0 to 3 hrs.
53	2	100 hrs.	SIMMS Cert.	SIMMS	6	14 yrs.	Master	7 or more yrs.
54	2	3 hrs.	SIMMS Cert.	Mixed	4	21 yrs.	Master	4 to 6 hrs.

Teacher Number	Question Number							
	Q-2	Q-4	Q-5	Q-6	Q-7	Q-9	Q-11	Q-13
55	2	0 hrs.	SIMMS Cert.	Mixed	6	2 yrs.	Bachelor	0 to 3 hrs.
56	3	10 hrs.	SIMMS Intro.	Non- SIMMS	4	33 yrs.	Bachelor	0 to 3 hrs.
57	2	100 hrs.	Non- SIMMS	Non- SIMMS	4	1 yr.	Bachelor	4 to 6 hrs.
58	2	90 hrs.	SIMMS Intro.	Non- SIMMS	3	2 yrs.	Bachelor	7 or more hrs.
59	3	60 hrs.	SIMMS Intro.	Non- SIMMS	3	15 yrs.	Master	0 to 3 hrs.
60	1	90 hrs.	Non- SIMMS	Non- SIMMS	N/A	25 yrs.	Master	0 to 3 hrs.
61	2	40 hrs.	SIMMS Cert.	Mixed	3	19 yrs.	Bachelor	4 to 6 hrs.
62	2	100 hrs.	SIMMS Cert.	SIMMS	6	7 yrs.	Bachelor	0 to 3 hrs.
63	2	9 hrs.	Non- SIMMS	Non- SIMMS	6	21.5 yrs.	Bachelor	4 to 6 hrs.
64	3	60 hrs.	SIMMS Trained	Mixed	2	10 yrs.	Bachelor	0 to 3 hrs.
65	2	480 hrs.	SIMMS Cert.	Mixed	3	10 yrs.	Master	0 to 3 hrs.
66	4	6 hrs.	Non- SIMMS	Non- SIMMS	3	2 yrs.	Master	0 to 3 hrs.
67	4	175 hrs.	SIMMS Cert.	Mixed	1	8 yrs.	Master	4 to 6 hrs.
68	4	30 hrs.	SIMMS Trained	SIMMS	3	16 yrs.	Master	7 or more hrs.
69	2	30 hrs.	Non- SIMMS	Non- SIMMS	6	22 yrs.	Master	0 to 3 hrs.
70	2	250 hrs.	SIMMS Cert.	Mixed	6	19 yrs.	Master	4 to 6 hrs.
71	2	100 hrs.	SIMMS Cert.	Mixed	3	6 hrs.	Bachelor	0 to 3 hrs.
72	2	200 hrs.	SIMMS Trained	Mixed	2	22 yrs.	Doctor	7 or more hrs.

Teacher Number	Question Number							
	Q-2	Q-4	Q-5	Q-6	Q-7	Q-9	Q-11	Q-13
73	3	150 hrs.	SIMMS Intro.	Mixed	6	3 yrs.	Bachelor	0 to 3 yrs.
74	2	135 hrs.	SIMMS Cert.	SIMMS	3	15 yrs.	Bachelor	4 to 6 hrs.
75	2	45 hrs.	Non- SIMMS	Non- SIMMS	5	22 yrs.	Master	0 to 3 yrs.
76	4	48 hrs.	Non- SIMMS	Non- SIMMS	6	1 yr.	Bachelor	0 to 3 yrs.
77	3	50 hrs.	Non- SIMMS	Non- SIMMS	6	1 yr.	Bachelor	0 to 3 yrs.
78	2	120 hrs.	SIMMS Cert.	SIMMS	6	24 yrs.	Bachelor	0 to 3 yrs.
79	3	50 hrs.	SIMMS Trained	Mixed	6	23 yrs.	Bachelor	0 to 3 yrs.
80	2	88 hrs.	Non- SIMMS	Non- SIMMS	6	2 yrs.	Bachelor	4 to 6 hrs.
81	3	80 hrs.	Non- SIMMS	Non- SIMMS	3	6 yrs.	Bachelor	0 to 3 yrs.
82	3	100 hrs.	SIMMS Cert.	Mixed	3	7 yrs.	Bachelor	0 to 3 yrs.
83	2	56 hrs.	Non- SIMMS	Non- SIMMS	1	4 yrs.	Bachelor	4 to 6 hrs.
84	2	190 hrs.	SIMMS Intro.	Non- SIMMS	5	14 yrs.	Bachelor	0 to 3 yrs.
85	3	100 hrs.	Non- SIMMS	Non- SIMMS	3	13 yrs.	Master	0 to 3 yrs.
86	3	200 hrs.	SIMMS Trained	Mixed	3	20 yrs.	Master	0 to 3 yrs.
87	2	420 hrs.	SIMMS Intro.	Non- SIMMS	6	17 hrs.	Bachelor	0 to 3 yrs.
88	2	25 hrs.	Non- SIMMS	Non- SIMMS	N/A	7 yrs.	Bachelor	0 to 3 yrs.
89	2	80 hrs.	SIMMS Trained	Mixed	4	2 yrs.	Bachelor	0 to 3 yrs.
90	3	50 hrs.	SIMMS Intro.	Non- SIMMS	1	15 hrs.	Bachelor	0 to 3 yrs.

## Question Number

Teacher Number	Q-2	Q-4	Q-5	Q-6	Q-7	Q-9	Q-11	Q-13
91	2	9 hrs.	Non-SIMMS	Non-SIMMS	1	28 yrs.	Master	4 to 6 hrs.
92	4	80 hrs.	Non-SIMMS	Non-SIMMS	4	15 yrs.	Master	0 to 3 hrs.
93	2	100 hrs.	SIMMS Trained	Mixed	2	7 yrs.	Bachelor	4 to 6 hrs.
94	2	100 hrs.	SIMMS Cert.	Mixed	1	18 yrs.	Bachelor	0 to 3 hrs.
95	3	N/A	N/A	SIMMS	2	14 yrs.	Master	4 to 6 hrs.
96	2	80 hrs.	SIMMS Cert.	SIMMS	3	18 yrs.	Master	0 to 3 hrs.
97	3	N/A	SIMMS Trained	Mixed	N/A	21 yrs.	Master	7 or more yrs.
98	2	3 hrs.	SIMMS Intro.	Non-SIMMS	4	24 yrs.	Master	0 to 3 hrs.
99	2	40 hrs.	SIMMS Cert.	SIMMS	3	27 yrs.	Bachelor	0 to 3 hrs.
100	3	20 hrs.	Non-SIMMS	Non-SIMMS	5	15 yrs.	Master	7 or more yrs.
101	2	40 hrs.	SIMMS Cert.	Mixed	4	21 yrs.	Master	4 to 6 hrs.
102	N/A	6 hrs.	Non-SIMMS	Non-SIMMS	6	8 yrs.	Bachelor	7 or more yrs.
103	3	45 hrs.	SIMMS Trained	Mixed	3	9.5 yrs.	Bachelor	0 to 3 hrs.
104	2	60 hrs.	Non-SIMMS	Non-SIMMS	1	28 yrs.	Bachelor	0 to 3 hrs.
105	4	150 hrs.	SIMMS Cert.	SIMMS	6	16 yrs.	Bachelor	7 or more yrs.
106	2	200 hrs.	SIMMS Cert.	SIMMS	6	3.5 yrs.	Bachelor	0 to 3 hrs.
107	3	140 hrs.	SIMMS Cert.	Mixed	6	4 yrs.	Bachelor	4 to 6 hrs.
108	2	12 hrs.	Non-SIMMS	Non-SIMMS	6	5 yrs.	Bachelor	4 to 6 hrs.

Teacher Number	Question Number							
	Q-2	Q-4	Q-5	Q-6	Q-7	Q-9	Q-11	Q-13
109	2	24 hrs.	SIMMS Cert.	SIMMS	3	3 yrs.	Bachelor	4 to 6 yrs.
110	3	15 hrs.	Non- SIMMS	Non- SIMMS	4	2 yrs.	Bachelor	4 to 6 yrs.

APPENDIX D  
TRANSCRIPTS OF THE INTERVIEWS

## Interview Number One

Teacher T1 has:

- a baccalaureate degree in mathematics,
- seven years of experience teaching mathematics in public schools,
- approximately 440 hours of SIMMS professional development, and
- both computers and graphing calculators available for his/her students.

DH: First one, describe the types of test questions used by your high school mathematics teacher to assess your understanding of mathematics.

T1: Um, paper and pencil largely, uh, computation, story problems.

DH: OK, And how 'bout describing the types of test questions used by your college mathematics teachers to assess your understanding of mathematics.

T1: Um, again, paper and pencil, computation and story problems. We also had to have an oral ah final for our degree.

DH: Could you explain that?

T1: We just meet uh, in front of a panel and they quiz us orally.

DH: For your...

T1: Bachelor's degree...

DH: In mathematics.

T1: Um hm.

DH: OK, uh, let's see ... I might come back to these but let's go on. List one, two or at most three factors that have most influenced the way that you assess your students and explain how they have influenced your assessment practices.

T1: OK, the uh, first one I listed was the my students' ability as test takers, how well do they actually perform on any kind of a math paper and pencil test, that was the first thing I look at. Um, and then the other thing, um, that I try to assess and or at least put in the minds of the students is the relevance of the math in their daily lives. So those are the two things that assess, that influence my assessment practices.

DH: How 'bout, uh, is there anything that ah, considering the way you were assessed in high school or college that has impacted how you assess now?

T1: Um, actually not too much. Um, I'm a good test taker so they don't ever bother, that doesn't ever bother me but my years as a Title One um, uh coordinator really brought home to me the fact that it doesn't matter what some people know, you never get it out of them if you tell them it's a test. 'Cuz they freeze up or they just can't for some reason get the information that they do know down on the paper so that someone else can look at it, and say, "Yeah, you have a good handle on this." While it is there it's probably not gonna show up on the paper.

DH: So how do you assess that information?

T1: Um, I can put the way, what I have done with my own students is that while I do give them some paper and pencil tests, I also allow them um, projects, presentations, group work, um open-ended questions as a test ... um, let's see, what else have we done?

DH: So we're getting into number 4 um, other methods that you use in your classroom to assess your understanding of mathematics.

T1: Right.

DH: I see.

T1: So research, uh, here's another one. Research um, plays a part in that too. We were looking at um, decay, ya know, um, exponential and logarithmic functions and decay and end growth things like that and I had them do a research paper as part of their assessment on that.

DH: OK.

T1: On that particular unit.

DH: OK, uh let's get to number 5 then; In order if importance, list which methods of assessment provide the most weight when you eventually assign a letter grade to a student's performance in the classroom.

T1: Well, they're all the same.

DH: So there's not one that weighs more than the other?

T1: No. The research paper will count as much as the pencil and paper test they're getting today.

DH: So, when they do a presentation, that counts as much as a project, counts the same as group work, etc....?

T1: Um hm. Uh, sometimes the group work I don't count as high, um, it depends on what the task I assigned the group and from my own personal observation as how the, how well the groups worked together.

DH: So, I take it...

T1: Group work is probably one that doesn't count as much. The rest of them do.

DH: So I take it you try to balance all the different methods of assessment when you finally assign a grade so one doesn't predominate and have undo influence. Is that accurate?

T1: Right. It really doesn't.

DH: OK.

T1: It doesn't have a tendency to skew the um, results, um part of ... the group I'm really thinking about here is my Algebra 2 students, and there are kids in there that need, just need a third math, not necessarily good mathematicians. And I don't think it's very fair, then, to assess them, although some of them are very good test takers, with, as the same as a student that's really highly motivated in mathematics.

DH: Gotcha.

T1: They're there because they need the math credit, not necessarily because they need the math knowledge. They get it, but, ya know, their reasons for taking the class in the first place are different from, say, a kid who's gonna be a, wants to be an engineer or ... so...

DH: OK

T1: That's the rest, now I have for that.

DH: Makes sense. Let's go on from there. Presently, there is discussion in the education journals of assessment of higher-order thinking skills, relative to Bloom's taxonomy, also other scales. As an expert in your field, can you comment upon the feasibility of

assessing your students at levels three through six of the taxonomy? That would be analysis, synthesis, and evaluation?

T1: Um, it's really hard to get a handle on how well they uh, analyze. I think that was one of the reasons I gave the, a research project. To see if they could write in paragraphs, um what their thoughts were. Um, I guess open-ended problems are another way to try to get at the analysis and the synthesis part. Um, story problems, I don't know, that's always a hard time.... it's hard for me to really try to get into their heads and figure out if they can figure this out. Or even if they really are motivated to do it.

DH: Gotcha.

T1: Sometimes I can kind of force it. And that works with, hm, let's see, probably ten of the nineteen kids that I have because nine are just trying to figure out what I want 'em to say so they can write it down quick and get on to something else.

DH: That's understandable. When you talk about open-ended problems, what do you mean by that so I know that we're talking the same language?

T1: OK, I'll give you an example. The one that we, that I assigned to my precalc kids had to do with a certain number of deer in a preserve, and um, the one was a certain percentage of the ones that were there were allowed to be hunted out every year. That was the "A" part of it, and the other part was just the certain flat number was allowed to be um, hunted out every year regardless of how many were in there. And for them, they had to draw a graph, two graphs, one for each "A" part and "B" part and come up with some ideas of what do you think's gonna happen to this deer population...

DH: Gotcha.

T1: ...in this preserve.

DH: So, did the...

T1: ...kinda like the trees, there was a tree one too where you cut out so many trees and plant so many trees...

DH: So this is something where they have to fill in some of the blanks as far as the information themselves, it's not all provided to them?

T1: Nope. They just have a certain three or four little, these, this is a situation, now what do you think's gonna happen...

DH: Gotcha.

T1: ... down the road?

DH: OK.

T1: And that I did allow that to be a group project. Um, there were just three girls in that class and I let them work on that together. Uh, they're not necessarily "red-hot" math students either; they just took the class for the challenge.

DH: What levels of Bloom's taxonomy do you believe your classroom tests assess your students?

T1: Honestly?

DH: Yes.

T1: I'm not sure, but ideally I'd like to have them particularly in the higher level math um, try to get through number six. Um, you know that's always the aim. Um, whether that actually happens, I'm a little fuzzy on whether that actually happens or not. We try to at least get to analysis, the fourth level. The rest of 'em, computation and basic

knowledge, those, we've hit pretty ... I don't have any problem with being able to assess the first three. When you get to five and six, I'm not sure.

DH: I understand what you're talking about.

T1: I try, ya know, we try to hit that but, um, we're, in our school district it's just going through a big, um, kind of a oh, not necessarily an overhaul, just looking over everything that we do. From curriculum through assessment to setting benchmarks to how are we gonna um, assess whether our students have hit the best benchmarks. We have a big community committee and we're trying to look at every area of the curriculum over the next two years. Those are some things we're trying to, trying to get a handle on. You know, district-wise too, and um, I don't know, we do our best to try to hit those higher levels and traditionally I don't think we have. We're working on it.

DH: Well...

T1: I'm not sure how successful we are.

DH: I can tell you from teaching at university level that uh, we have about the same problems that you do, so ... it's not a thing where we're uh ... I'm trying to uh ... oh, how would you put it? I'm not trying to say that you should be doing a certain thing, I'm looking at also what I'm doing and saying I know some of the problems that you encounter. So, it doesn't change...

T1: You have 'em after we have 'em so...

DH: That's true. But, uh, it's the same problems; we all have the same problems we have to deal with. Um, just finally, going back to one and two, you had mentioned the paper and pencil, the computation and the story problems, is that what you consider um, kind of like the traditional assessment?

T1: Um hm.

DH: And so you saw that at the high school and you saw that at the college level and the only difference at the college level is that you had that oral final.

T1: Um hm.

DH: How, how did that effect you?

T1: I thought it was great. Um, I know most uh, undergrad programs don't require an oral final, but I thought it was great and it didn't bother me at all. In fact I took it at the end of my junior year just so I would have it out of my way. Um, I liked it. And although I'm a test taker, it wouldn't have bothered me to have any other kind of final either. Some of the, ya know, of my classmates were petrified. We had a oral finals in our um, major area, plus we also had oral finals in philosophy.

DH: Oh.

T1: In order to get a bachelor's degree.

DH: Is this something where you had to bring stuff together then?

T1: Um, kind of.

DH: Or...

T1: Depends, ya know, you had to take so many certain number of classes and then get announced or apply to take your orals and ah... Yeah, one of the ... ya know one of the questions they asked on the math final was to come up with the formula for the derivative.

DH: Oh. OK.

T1: To walk through how that comes out. To see ... I didn't have a problem with it, I thought it was great fun. I guess I'm more into academic challenges than some people are.

DH: Well, it might be that that uh, method of assessment is uh, you're comfortable with that too.

T1: I am.

DH: And uh, I guess that kind of varies with students. I know I've got a ... I'm teaching a calc class for students that will probably never use it and I tell ya, they are very scared. It's enough just to use paper and pencil type assessment. I think if I had to do oral, it would just scare the heck out of many of them.

T1: Right.

DH: Yep.

T1: Probably would just blow 'em away.

DH: I think that takes care of the interview. That takes care of my questions. And uh, just want to tell ya, appreciate your time.

T1: Oh, no problem. If you have ... if you need any more information, or you want me to do anything else for you, let me know.

DH: OK. Let's see, I got your packet in the mail, is that right?

T1: Should have. Yeah, I mailed it the other day.

DH: Yeah, I got two uh, yesterday, and I think yours was in there so that should take care of everything.

T1: OK.

DH: Thanks a lot.

T1: Oh, no problem. We'll see you.

DH: Um hm.

T1: Bye now.

DH: Bye.

## Interview Number Two

Teacher T2 has:

- a master degree in secondary education,
- 37 years of experience teaching in public schools,
- approximately 20 hours of SIMMS professional development, and
- both computers and graphing calculators available for his/her students.

DH: OK. Describe the types of test questions used by your high school mathematics teachers to assess your understanding of mathematics.

T2: Uh, I think on that, it's been a long time since I was in high school but uh, I think primarily problem solving, short answer-type questions, maybe some completion, possibly, once in a while, multiple choice.

DH: OK. I'm writing down at the same time in case something happens to the tape. Um, the problem solving you're talking about, are those the story problems?

T2: Story problems or just, just problems where ya gotta solve, like solving an equation or that sort of thing.

DH: Oh, OK. Describe the types of test questions used by your college mathematics teachers to assess your understanding of mathematics.

T2: I think, probably, primarily I graduated down at Montana State, but again there was a heavy emphasis on problem solving, both verbal problems and just solving various types of problems, equations ... various calculus problems, things like that. Some short answer, probably some multiple choice, but not a lot.

DH: Was it somewhat similar to what you had in high school? As far as the type of questions, not the subject material, but the type ...?

T2: Yes, I would say ... I would say it was. Yeah, probably. Again, it's been awhile too, so...

DH: Yeah. OK. List one, two, or at most three factors that have most influenced the way that you assess your students and explain how they have influenced your assessment practices. And, what I mean by that is, is there things that have, uh, have happened to you or the way that you were taught or um, professional development that you have received or anything like that that has determined how you assess your students?

T2: I think my, my major theme is I'm always concerned with trying to determine if the students have mastered the key skills...

DH: OK.

T2: ...truly important in there ... yeah.

DH: Did that come from your education or why do you choose the basic skills, um?

T2: Well, I think in part from my own education...

DH: OK.

T2: ...but also some uh, college courses I took like uh, uh, took one that \*\*\*\* used to teach down there, uh, the methods course for mathematics and I picked some ideas up from that years ago.

DH: Oh, OK. To gain more detail about your assessment practices in the classroom, describe to me other methods than regular classroom tests that you use to assess your students understanding of mathematics?

T2: Uh, one form of assessment for me is their daily work, or homework.

DH: OK.

T2: I go through that ... I don't rigorously go through it but we check the assignments every day and I go over problems for 'em and uh, I look at their homework to see what they're doing. Sometimes I'll have them redo it. Uh, another thing I kind of assess how they can respond with classroom discussions. I'll ask a lot of questions and try to get the kids involved with discussion and that. Especially in geometry classes like that.

DH: OK.

T2: And just verbal question and answer things. If they have problems they want help or, I encourage the kids to ask questions anytime they're not understanding or something like that.

DH: OK. In order of importance, list which methods of assessment provide the most weight when you eventually assign a letter grade to a student's performances in the classroom.

T2: OK. Most weight would be tests. And then follow, I follow that up with quizzes in between major chapter tests. I like to give at least one quiz during the chapter somewhere midway through. And then the other factor, of course, is their daily work.

DH: OK.

T2: And I do count that, counts less than half, but still is a fairly major factor in overall assessment.

DH: OK. Presently, there is discussion in the education journals of assessment of higher-order thinking skills, and that's ... I'm talking relative to Bloom's taxonomy, I know there's other ones. Um, as an expert in your field, comment upon the feasibility of assessing your students at, uh, for higher order thinking skills.

T2: That's level three through six?

DH: Yeah, that would be uh, application, um ... uh, analysis, synthesis, um ... uh track ... evaluation, I believe the other one is...

T2: Um hm, yeah. Well, I looked that over a little this morning I ... in all honesty I hadn't looked at Bloom's taxonomy for quite a few years. I've run into it in education courses...

DH: Um hm.

T2: ...a few years, of course, but ... uh, I would say application is very important, essential part of evaluation. How well they can apply what they've learned. Verbal problems, that type of thing. Analysis, breaking things down into their component parts... I think that's an essential step too, and then synthesis one I think is pretty important...

DH: Um hm.

T2: I would say, to me, those three are pretty important. Of course evaluation, too, overall.

DH: Um hm.

T2: So I would say those are the most important to me.

DH: And do you feel that in your classroom that you, um ... catch those quite often or sometimes, or, um ... does it depend on the classroom?

T2: Well, depends a little on the class, and the text we're using for ah ... that one on application, there are a lot of ... well there are Algebra 2 and Geometry applications, their books are quite a bit of application situations. They can apply what they learned. I happened to teach a couple of honors classes in geometry and I think that's important there.

DH: Just out of my own, just for my own curiosity, what book do you use for Geometry?

T2: What book do we use for Geometry? Uh, it's an Addison Wesley book. Uh, can't think of the name of it right off, it's one of their most recent ones. I think it's called ... there's something about focus in the whole series for Algebra/Geometry and all, it's called, "Focus". This one is called "Focus on Geometry" I think.

DH: OK.

T2: Or something like that, it's pretty recent though. We've only had them about three years.

DH: The reason I was asking is I ... I've talked with teachers in this area too ... Belgrade, Livingston, and they're going over to different Geometry books and um, oh, I think the one they had was, "Geometry: An Inductive Approach" and uh, their trend is to get away from so much of the proof theorem initially and put it towards the end of the school year, and I'm just trying to see what other teachers or other schools are doing and where the trends are going right now.

T2: Yeah, well this book and series we have is still the ... does quite a bit with proof . It don't do quite as much as their previous text did. But I still feel that proof is fairly important. I think that kids learn reasoning and uh, logic skills, stuff like that. So I push proofs pretty hard.

DH: OK. And I think you pretty much answered the last one of which levels of Bloom's taxonomy do you believe your classroom tests assess your students? Um, is there any more you can add to that as far as um ... the assessment of higher order thinking skills, problems, um ... or uh ... methods at work, or anything to that effect?

T2: You mean for evaluation, or?

DH: Yeah, when you ... yeah, when you assess high order thinking skills, are there problems that occur? Are there things that you have found that work that make it easier to do or...?

T2: Well, ya know, there's some problems, and I'm one that's pretty much used a lot of the, the uh ... factory-made tests. What I do is I typically pick from their test booklets that go along with the books but I throw tests together from that so I get a reasonable length that they can do in an hour, and stuff like that. I've tried to get some problems in there, kind of a mix, some that test for higher level skills, some that only test for the basics to make sure they know a little of it.

DH: Um hm, yep.

T2: Yeah, and that, if you're down to that question 7 there, I think probably at my level, mostly level three to six are the ones, but probably some basic things in level two also ...

DH: OK.

T2: ...some test questions that just, ya gotta ask the basics, do they really know what ... where they're coming from.

DH: Yeah, and I think the main idea with the taxonomy is not that you focus on one end of the spectrum or the other but more that there's a balance in there and one thing that impresses me, from what I'm hearing from teachers is, is you really have to consider the ability level of the students before you consider, you know, what level you assess.

T2: Oh, definitely you do, yeah.

DH: So you can't always hit those higher levels when you have students that just don't have the basics down.

T2: Yeah, we run into that with the honors classes quite a bit. Most of those kids are at a pretty good level, pretty sharp kids.

DH: Hm.

T2: But we've got a few in there too that even struggle a little bit there and aren't quite up to the level of the others. And I've found that's not a bad deal because, I've found that some of those kids that I think, being exposed to the veteran kids, the higher caliber kids, really helps them out.

DH: OK.

T2: They've ... I've had a number of kids that I'm teaching, you know, there's Geometry for about three or four years now, I guess. And uh, I've found, every year, I get a few kids that I think a lot of people consider marginal and I've had quite a good success, I think, in bringing those kids up in their grades during the year. And I ... that's why I'm not in favor of keeping ... weeding kids like that out if they really want to be there and they're willing to work ... I've had good luck with some, uh, improving quite a bit.

DH: Hm.

T2: I think just being exposed to the better caliber student helps some of the more marginal ones sometimes.

DH: Um hm. OK. That makes sense. Well that takes care of the interview.

T2: OK.

DH: I appreciate your time. Uh...

T2: Glad I could help you out on it.

DH: And then uh, I think the only other thing I need, unless I've received it already, if you could send, uh sample tests?

T2: Yeah, I haven't sent those out. I noticed that today.

DH: OK.

T2: Last week I was pretty busy, because I've been out of school for awhile...

DH: Yeah, yeah, you'd mentioned that...

T2: ...this earlier, and I didn't get to it 'til this morning.

DH: Is your ... is your leg better now?

T2: It's getting' there, yeah. It's much better than it was last week.

DH: OK.

T2: But, uh ... do you want me to just send that down as quick as I can?

DH: In the next couple weeks would be fine. It's not a big hurry, uh, just, if you can get it done eventually ... don't ... don't ... get your other stuff done first, but, just uh...

T2: I'll try to get it down to ya in the next few days, because I'm one of those, if I don't get on something real soon, sometimes it gets buried in ... so I'll ... you just want about three copies of tests, is that it?

DH: Yeah, uh ... three different copies of tests and uh ... uh, if you'd put the ability level of the students general ability level of the students, and then if there's questions that you consider higher level, if you'd just circle the number on 'em.

T2: Yeah, kinda just indicate which are higher level...?

DH: Yeah, I appreciate that.

T2: I'll try and do that for you then.

DH: OK. Well thanks again for your time, and have a good day.

T2: Yeah, you bet. Thanks, Dave.

DH: Um'hm.

T2: OK, we'll see ya then.

DH: Yep. Bye.

## Interview Number Three

Teacher T3 has:

- a baccalaureate degree in mathematics education,
- 25 years of experience teaching in public schools,
- approximately 60 hours of SIMMS professional development, and
- both computers and graphing calculators available for his/her students.

DH: First one, describe the types of test questions used by your high school mathematics teachers to assess your understanding of mathematics.

T3: Oh, well those test questions said um, factor this problem, uh ... use a quadratic formula on this one. I mean, there wasn't like, those story problems that we knew about, you know, those normally weren't on tests. They were at the end of every lesson and sometimes, maybe a section of the chapter was on story problems, but they weren't disbursed. We never applied anything we learned, if that was what story problems were for.

DH: Yeah, I know what you're talkin' about. So mainly a lot of computation?

T3: A lot of computations.

DH: Gotcha. Describe the types of test questions used by your college mathematics teachers to assess your understanding of mathematics.

T3: College math, same thing.

DH: Same thing.

T3: Um hm.

DH: Mainly computational?

T3: Mainly computational.

DH: OK. I'm taking notes at the same time just in case the recorder goes on the blink. Yes, that's happened to a few people, then they kick themselves.

T3: Oh no.

DH: Third question, list one, two, or at most three factors that have most influenced the way that you assess your students and explain how they have influenced your assessment practices.

T3: OK, say that again.

DH: Well, I'm looking at things in your background that have influenced how you assess students and why they have influenced you. For example, maybe somebody, when they went through school, everything was computational. They hated it and they decided, "I'm not gonna do that to my student."

T3: Oh.

DH: So, that's just an example. What things have uh ... helped you decide how you will assess your students?

T3: OK. Outside of the SIMMS program?

DH: SIMMS, anything. Any, any three factors you think are most important.

T3: Well, the only one that I can even think about is um ... a superintendent that I had in the last, oh let's see ... he hasn't been here for two years, so about five or six years ago,

when he first came here he was a math instructor and he influenced me a lot in the way that I teach today.

DH: How so?

T3: He was um ... real big on doing discovery kind of learning.

DH: Um hm.

T3: And I didn't do that at all in my classroom before him. So he was the first one who actually got me thinking about, "Oh, there's another way?"

DH: OK.

T3: And then right along with him came the SIMMS program.

DH: Um hm.

T3: And they just compliment each other and that's how I actually got going in what I'm doing right now.

DH: I see.

T3: It changed my whole style of teaching. It changed my whole style of assessment. I used to hand-write all my tests because they were easy and now I have to type them on a word processor.

DH: Hm.

T3: Of the assessment ... there's so many other forms of assessment now besides tests and that's ... I used to only do tests.

DH: Uh huh.

T3: Now I do reports, ya know research projects and um ... all kinds of little things.

DH: OK. That actually leads into the next one that's other methods in regular classroom tests that you use to assess your students. You mentioned reports, and what else?

T3: Reports and research projects.

DH: Research projects. OK.

T3: Um ... they are also assessed on uh ... group participation. We do a lot of group work.

DH: Um hm. Group participation.

T3: And then they still have tests and quizzes, but my tests and quizzes are not ... they don't test uh ... general knowledge anymore.

DH: They're geared more towards what?

T3: More open-ended with um ... problem solving approach, kind of ... uh, questions, ya know.

DH: Yep.

T3: OK.

DH: Yep, I think I know what you're talking about. So, tests and quizzes more towards problem solving rather than, you mentioned, what was the other one?

T3: Um...

DH: Rather than...

T3: Rather than uh ... uh...

DH: Computational?

T3: Computation, there you go. Um hm.

DH: Gotcha. Fifth one, in order of importance, list which methods of assessment provide the most weight when you eventually assign a letter grade to a student's performance in the classroom.

T3: My tests and quizzes still do...

DH: Um hm.

T3: ...count the most.

DH: Um hm.

T3: Um ... I usually assign, now I have three categories that, right now, that I throw everything into and tests and quizzes and projects ... projects being research projects.

DH: Um hm.

T3: Those count 60% of their grade.

DH: So tests, quizzes and the research projects are kind of combined together?

T3: Yep.

DH: OK. And then, let's see I take it, under that is just the uh ... reports and group participation?

T3: Group is um ... pretty much all by itself and I do a 10% of the grade on that. This is an individual thing with me. I've just decided to do this and it seems to uh ... it seems to help every kid participate instead of having a group of three and one watching and two doing.

DH: Gotcha.

T3: Ya know. Their grade will actually suffer because of that. Because it counts, that's a category by itself, counts 10%.

DH: OK. So, that would leave reports probably around 30%?

T3: Yep. Homework, I also grade homework.

DH: Oh. OK. How do you put that in priority, uh ... ya got the tests, quizzes and research projects...

T3: Got homework and, homework and the upkeep of their notebooks um ... and minor reports, those will be in the other 30%.

DH: Gotcha. OK. And we're almost done here.

T3: OK.

DH: Presently, there is discussion in the education journals of assessment of higher-order thinking skills, relative to Bloom's taxonomy, well actually several taxonomies, but Bloom's is one. As an expert in your field, comment upon the feasibility of assessing your students at levels three through six, three through six are application, um ... synthesis, analysis, evaluation.

T3: Assess my students?

DH: What's the feasibility, does it work out to assess those things in the classroom? If so, how often, if not...

T3: I think we do assess them in that ... in fact I probably assess my uh, my students using this curriculum in that kind of thing more so than I do in any other thing. I mean, more so than, than the lower level thinking, the computation kind...

DH: Um hm.

T3: For one thing, when we're using calculators, I don't ever really get to know whether they know their multiplication tables or if they're really good at doing mental math, or, ya know ... I don't test that at all.

DH: Um hm.

T3: They don't get tested. So the higher level thinking is what actually gets tested, and I think my kids do better on that.

DH: Um hm. OK.

T3: I don't know if that answered that question.

DH: Actually, it uh ... so you feel in your classroom that you can assess those higher levels without a great deal of a problem and you put less emphasis on the, say level one, level two, which is more computational and memory.

T3: Um hm, yep.

DH: OK.

T3: And therefore, sometimes I'm surprised at my students' lack of ability to do the low order stuff.

DH: Oh.

T3: I've seen it and I go, "Oh my gosh, they can do all this really tough stuff, but they can't do, ya know really, I mean, it's just kind of surprising."

DH: Actually, it's one of those things ... this is just my belief, I think that what happens is, is that we have to assess as all levels, it's just that sometimes we don't have the time so we have the trade-offs that go on.

T3: Uh huh.

DH: And I ... I guess, theoretically it'd be great if we could assess at every level and ... but I guess we gotta decide what's the priority? Do we want the higher level, do we want the lower level? Which one's gonna suffer and...

T3: Um hm.

DH: I deal with it I think.

T3: Yep, and I think ya know, prior to the curriculum I'm using now, I hardly ever assessed at this level.

DH: Hm.

T3: So...

DH: OK. Let's see ... I think that answers the questions.

T3: OK.

DH: Uh ... appreciate uh, you taking the time for this, and uh...

T3: OK, and now I haven't looked through the packet yet. Do you need some stuff from me?

DH: Yeah, I was wondering if you could send uh ... three different tests that you've used in the classroom and, it's in the letter, but indicate on the test the level of the ... the ability level of the students, high, medium or low. And then if there's questions on there that you consider higher level questions, just circle the numbers on them.

T3: OK.

DH: And then, uh ... somewhere on the envelope or on the inside put your name so I know these are yours.

T3: OK.

DH: So far, people have been good, but I should have maybe mentioned that, so ... um...

T3: And you need these by...?

DH: Oh, if I could get them in the next couple weeks or so. I guess I say that so that um ... it's easy for myself or somebody else that if, you don't do it right away you may forget about it.

T3: Right.

DH: So, if you could do it in the next couple weeks, that's fast enough for me, that's...

T3: All right.

DH: That's perfect.

T3: All right.

DH: Thanks a lot for your time.

T3: You bet. Um hm, b'bye.

DH: Bye.

## Interview Number Four

Teacher T4 has:

- a master degree in mathematics education,
- 15 years of experience teaching in public schools,
- approximately 480 hours of SIMMS professional development, and
- computers, internet, and graphing calculators available for his/her students.

DH: First question, describe the types of test questions used by your high school mathematics teachers to assess your understanding of mathematics.

T4: Uh, as far as uh ... uh, types of test questions? You mean uh, open-ended, multiple choice, fill in the blank, is that what...?

DH: Yeah. Um hm.

T4: OK, uh, I'd say a variety, uh ... everything from uh, I don't know if anyone uses true/false but I say everywhere from multiple guess to essay response.

DH: So those are your high school mathematics teachers used the a variety of questions?

T4: Yeah.

DH: And that would, like I said, uh ... that would be er, like you were saying, that would include uh, um ... fill in the blank, open-ended, um...

T4: ...essay...

DH: Essay, and math teachers use those?

T4: Yes.

DH: OK. Describe the types of test questions used by your college mathematics teachers to assess your understanding of mathematics.

T4: Uh ... same list, adding true/false.

DH: OK. And, just going back to the high school again, um ... were the assessments mainly pencil and paper through tests and quizzes, or were there other uh ... forms of assessment used?

T4: Uh ... well, uh, informal assessment was used frequently and uh, we mostly used projects for assessment. Presentations...

DH: And that's when you were going to high school?

T4: Oh, excuse me, when I was a high school student?

DH: Yeah, the ... by your high school mathematics teachers when you went through high school. That's why I was asking on that because um...

T4: Oh, am I misunderstanding this interview then? I thought you were speaking about...

DH: Oh I...

T4: ...assessments here at this high school.

DH: I am gonna ask about you, but first I'm wondering what...

T4: ...backtrack then because I'm answering relative to my teaching...

DH: Yeah, and that I will get to but what I want to know is kind of like uh ... how was it for you when you came through, and then I want to know what you're doing so I can kinda get an idea of ...of has there been an effect here.

T4: We better back up some more then, I misunderstood the...

DH: OK.

T4: ...focus of your questions.

DH: OK. Let's go to number one then, describe the types of test questions used by your high school mathematics teacher to assess your understanding of mathematics.

T4: Uh ... true/false, multiple guess, fill in the blank, free response.

DH: OK. So, more traditional assessment?

T4: Traditional ... yeah, very traditional assessment.

DH: OK. That's kind of why I was asking the extra questions. And is that the same thing with the college level teachers?

T4: Uh ... most of the assessment done by most of my college level teachers were traditional assessment, yes.

DH: Um ... so were there differences for some of your college level mathematics teachers?

T4: Uh, I've uh ... had some very innovative college mathematics teachers, some not so innovative so...

DH: OK.

T4: ...covers the gambit.

DH: So you had both traditional and innovative.

T4: Yeah.

DH: OK. Let's keep going here. Um ... list one, two or at most three factors that have most influenced the way that you assess your students and explain how they have influenced your assessment practices. Now we're talking about you yourself and things that have influenced how you assess you students.

T4: OK, um ... I think my uh, SIMMS Teacher Leader training has been uh, very influential the way I assess my students.

DH: Um hm.

T4: Also, uh ... ideas from journals and conferences.

DH: OK.

T4: And uh, I mean you can't get away from the fact that your own experiences influence the way that you operate so...

DH: Um hm.

T4: That's certainly operational.

DH: What about your own experiences, uh, can you kinda explain what you mean there?

T4: Oh, I mean, most of us come from a fairly traditional background as far as assessment...

DH: Um hm.

T4: ...and curriculum, so those are the overriding influences.

DH: Gotcha.

T4: ...and that's kind of our ... the base from which we launch ourselves from.

DH: Exactly. I understand now.

T4: The bottom line so to speak.

DH: OK. To gain more details about your assessment practices in the classroom, describe to me other methods than regular classroom tests that you use to assess your

students understanding of mathematics. That's what we were talking about ... uh ... you were talking about the first time. So the other things that you use and uh, tests and quizzes, or...

T4: OK, informal assessment is used probably more frequently than anything.

DH: Informal. What do you mean by that?

T4: Uh ... in classroom interactions on a daily basis...

DH: Um hm.

T4: Uh ... I'm differentiating assessment uh ... from evaluation.

DH: Exactly.

T4: ...that's one that I favor. (Unintelligible) Dave how long will this be?

DH: This will take about another 5 minutes, we'll be done.

T4: OK. All right, I'm back.

DH: So, we were talking about informal classroom interaction, or informal being classroom interaction as far as different assessment...

T4: Observation, directed questioning, uh ... interviewing, um ... mostly observational assessment. And then also uh ... you know the traditional in quizzes and tests and homework assignments and short and long term projects, presentations...

DH: OK.

T4: Uh ... those things are used uh ... probably more towards the evaluation end.

DH: Um hm.

T4: Do you understand where I'm coming from?

DH: I guess when I define...

T4: ...Assess ... I just want to see if you understand.

DH: Um hm.

T4: ...Evaluate, I assign a grade to that.

DH: Exactly. Yep, we're talking about the same thing. And uh, I guess when I think of assessment, too, I think of ... I can use ... I can evaluate an assessment so I assess something, I look at where they're sitting and I can assign a value to it and evaluate it. If you know what I mean.

T4: Yes.

DH: OK.

T4: Uh, as far as the informal assessments, I ... I don't evaluate that with a grade...

DH: Um hm.

T4: Uh ... however, I may evaluate it as far as feedback to the student.

DH: Gotcha. OK. In order of importance, list which methods of assessment provide the most weight when you eventually assign a letter grade to a student's performance in the classroom.

T4: Uh ... letter grades have been predominately balanced between daily work and tests, uh ... although projects and quizzes have also been included on a lesser priority.

DH: Um hm. OK. And let's see ... daily work, your talking about homework?

T4: Homework, yes.

DH: Gotcha. So number one would be the homework and the tests and number two would be projects and quizzes?

T4: Yes.

DH: OK. And last two here ... presently, there is discussion in the education journals of assessment of higher-order thinking skills, relative to Bloom's taxonomy, there's other taxonomies but uh, one of them is Bloom's. As an expert in your field, comment upon the feasibility of assessing your students at levels three through six of Bloom's taxonomy. That's application, uh um ... synthesis, analysis, evaluation.

T4: Uh... I think from a practical standpoint, those are extremely difficult ... uh ... to assess mostly because uh, they are time intensive.

DH: Yep.

T4: And, uh, if you have a student load of 120 to 150 students, uh, it becomes difficult to do that and balance your professional life with your personal life and...

DH: Um hm.

T4: ...uh, it's so ... I think as a generalization, uh ... most educators including myself, probably tend not to gravitate towards that end of the spectrum.

DH: Um hm.

T4: Although, um ... I do try to make an effort to reflect them in my assessments.

DH: OK.

T4: I sent you uh ... I sent you some copies of some tests. I don't know if you've received those.

DH: Yep. I believe I've got those.

T4: Yeah, OK.

DH: I'll look those over, uh...

T4: Let me know if that's accurate or not but...

DH: No, and I understand what you're talking about, it's...

T4: It's a practical issue there, where...

DH: Um hm.

T4: I'm often in my classroom, uh ... between six and seven in the morning and I leave between four and five in the afternoon...

DH: Yep.

T4: And I spend most of my day in my room doing um ... curriculum, or ya know, developing materials, assessing materials, assessing student work, so uh, ya just kind of ... something has to give somewhere in the process.

DH: Yeah.

T4: I think, uh, maybe student loads is an issue that tends to interfere with assessment at the higher levels of Bloom's taxonomy or any other taxonomy...

DH: Um hm.

T4: But, uh, on the other hand, uh ... I mean, I tell my kids flat out, I don't uh, I don't consider rote memorization as learning...

DH: Um hm.

T4: Uh, what I mean is, that's an overstatement. It is at the lowest levels.

DH: Um hm. Exactly.

T4: And so that's not what I'm going to assess. I rarely ask the kids to memorize anything. I ask them to apply it, um ... uh ... I allow kids to use their notes when they do an assessment in class.

DH: Um hm.

T4: Uh, from the standpoint of uh ... I want them to be able to find what they need to use, and determine when to use it. How to use it...

DH: Um hm.

T4: How to apply it appropriately, uh ... not to necessarily memorize it but, uh ... most people in the profession realize that we often have to go to a resource book to find what it is that we need to know and determine how to use it. Uh, we just can't contain every piece of information we're presented with.

DH: Um hm.

T4: So it's more problem solving, and uh ... approach rather than memorization of specific facts.

DH: Um hm.

T4: Although, that is also an important element, obviously.

DH: Um hm.

T4: So ... can't completely ignore it. I mean a kid has to be able to tell you what the definition of sine is. That's, in my mind, about as low a level of learning as I've, as I can think of.

DH: Um hm.

T4: That's just me to you. Have it memorized or you don't.

DH: Um hm. Yeah, what you say makes sense. I mean you've got more students than what I have to deal with in one day and you have to assess all these students, and uh, just myself, with my research on assessing higher level, those are not only difficult questions to make up, they are very difficult to grade.

T4: Uh huh.

DH: So ... uh, person has only so many hours in one day.

T4: That's right.

DH: And last question, I think you've kind of answered this ... At what levels of Bloom's taxonomy do you believe your classroom tests assess your students?

T4: Um ... I tend towards application.

DH: Application? So, of course, uh ... we assume, like the level one and level two are in there but you ... you, you're saying that you also get up to the level of application?

T4: Yeah.

DH: Is that correct? OK. That should do it, uh ... I appreciate your time.

T4: You bet, David.

DH: And this will help me out with my research that I'm doing.

T4: Now is this for a doctoral thesis? Or...

DH: Yes, this is ... uh, and I'm trying to do something that uh, I ... I'm hoping that here at the university they can use this information. I ... I really hate the idea of doing something like this and then having it stuffed in a journal somewhere and no one ever even seeing it or using it.

T4: Uh huh.

DH: So I'm hoping that uh ... uh, what I find out will, you know, maybe make a difference here at this university, or even around the state.

T4: OK, um, do you plan on making any results of this available to the people that were involved...?

DH: Yeah, and did you indicate on your card that you wanted a copy of the results?

T4: I believe I did.

DH: I'm gonna write your name down one more time and double-check my files. I've been indicating all the people that wanted stuff back on it, and I'll double check to make sure your name is on there.

T4: All right, Dave.

DH: And the final bottom line is ... is if you ... if for some reason by next fall you don't receive something, you can contact Dr. Burke, and he'll have a copy of it. But I'll ... I'll make sure that you get it.

T4: All right.

DH: OK?

T4: Well, thank you very much, David, and best of luck on your research.

DH: Thank you.

T4: OK

DH: Talk to ya later, then.

T4: You too.

DH: Um hm.

T4: Bye

DH: Bye

## Interview Number Five

Teacher T5 has:

- a master degree in mathematics,
- 28 years of experience teaching in public schools,
- approximately 400 hours of SIMMS professional development, and
- computers and graphing calculators available for his/her students.

The first part of this interview was accidentally not recorded.

For the first question, the teacher said that he/she was assessed in a traditional manner in high school and that assessment mainly focused on rote learning. For the second question, the teacher said that assessment was different at the college level because it focused more on proof, graduate students were required to critique and extend mathematics journal articles, and one mathematics educator did extensions to the regular curriculum. For the third question, the teacher said that writing for the SIMMS Project and involvement in the creation of the Advanced Placement Calculus exams have had the most influence on his/her assessment practices. For the fourth question, the teacher said that he/she assesses students through a student/teacher dialogue that is directed by students' questions and interests, having students read mathematics during class, and observations. For the fifth question, the teacher said that he/she weighs exams and quizzes most heavily when assigning a letter grade to a student's performance.

The interview picks up when the teacher is comparing his/her preparation for comprehensive exams to his/her student's preparation for college entrance exams.

T5: Ya know, I mean, man alive! The time I waste on those, ya know, for 2 and a half hours worth of oral exam I spent, ya know, 500 times that, ya know, preparing for it.

DH: Um hm.

T5: Ya know, and I tell the kids, I say, ya know specifically what to study, ya know, and then help them, give them some confidence in what they study and it kind of eliminates some of the stress involved with preparing for these...

DH: Um hm.

T5: And ah, and like I tell them, if you've done a good job with your homework, study your homework problem, ya know, prior to the exam, you'll do OK. Some do.

DH: Um hm.

T5: And ah, so it works out pretty well that way.

DH: Hm. Presently there is discussion in the education journals of assessment of higher-order thinking skills, relative to Bloom's taxonomy, and I know there's other ways of... of other taxonomies, but with respect to Bloom's. As an expert in your field, comment upon the feasibility of assessing your students at levels three through six, that's applications, synthesis, analysis, evaluation ... those sorts of things.

T5: Well I ... I think I tend to use a little bit of all of it. Applications probably more than anything else.

DH: Um hm.

T5: Uh, but like I say, the way I'm, the way I run my tests, everything's open-ended...

DH: Um hm.

T5: ...ya know, they have to present solutions in some sort of organized fashion...

DH: Um hm.

T5: ...for full credit, at least. Um, I give a lot of part credit. Ya know, like if they get started wrong then work the problem the right ... correct from there on, they will still get some part credit.

DH: Um hm.

T5: Uh ... and uh, and I really look to ... I learn, ya know, I read their problems. I actually read their solutions so I don't do multiple choice questions. Uh, I don't do fill in the blank very often.

DH: Um hm.

T5: Um, I don't know I ... evaluations, the very last one though, I'm not really sure ... ya know, where they actually ... there are certain situations where they have to come up with a solution, and then say, well OK, is this reasonable. Cuz I do ask a lot of questions that have no solution.

DH: Um hm.

T5: Ya know, so there is a little bit of ... of level 6, where they actually have to say, "OK, this is what I got, does it make sense?" Or, ya know, when they're doing, um, trig sorts of things, ya know, trig equations, solving in that sort of thing ... trig applications...

DH: Um hm.

T5: ...often times they have to select one, or maybe two or three possible solutions, some which don't work and some which will work.

DH: Um hm.

T5: Ya know, I guess that's what six is referring to.

DH: Now, you mentioned using the open-ended and so on and so forth, um ... how do you, just from ah ... my curiosity, how do you find the time to correct that? Or do you just focus on the tests themselves and the open-ended questions and spend your time correcting those? Uh, I ... I ... the reason I ask is I have uh ... when I talk to other teachers ... there's this problem with some of them where they use the lower level because they just don't have the time to correct open-ended questions for uh ... 100 or 200 students coming through their class each day. And then another one said I use higher level but that means I'm not able to assess the lower skills as much.

T5: Uh, I think you can see both, cuz you can ... you can see the arithmetic as they go through the problems, plus you can follow their analysis or just ... ya know I mean, I don't know how they can tell cuz it's the work is a road map the way the kid's doing the problems...

DH: Exactly.

T5: And then you can see the arithmetic, their applications...

DH: Um hm.

T5: and then, and like on some problems, they have to make a final decision about accuracy...

DH: Um hm.

T5: ...it's all there ... I don't know how they can fairly judge a student, uh ... without doing that.

DH: I see what you're talking about. And then, how many classes do you normally teach a day?

T5: Uh ... I've got one, two, three, four, five, six ... counting ... one course is programming and that takes the longest to grade...

DH: Then you've got a heavy load there.

T5: Yeah.

DH: I ... I just out of my own curiosity, how you find the time to, to get through all the um ... assessment, um...

T5: Work nights.

DH: You ... um...

T5: Serious

DH: I understand. I know what you mean. I ... I know exactly what you're talking about, I just, ya know, it's ... it's ... it's one of those things where um ... I ... I see teachers that do that and I have a lot of respect for them, but, boy, it's a tough load. I mean, you're doing something for these students that's very important, and yet at the same time it's a very tough load because, like you said, you spend a lot of time, evenings, taking care of that stuff.

T5: I give a lot of tests on Fridays so I can use Sundays.

DH: Oh.

T5: But, no. This is ... see, one thing about my classes, if they take a test on Thursday, they get it back on Friday.

DH: Um hm.

T5: I mean, there's no way I want to make the students take an exam and wait to get it back. He gets it back the next class period. And it's just the way, ya know, I might spend four hours on a Tuesday night grading papers ... but it's just the way I choose to do things. Ya know, I've ... I've got my own thoughts, I guess, what professional teacher means. That's one of them.

DH: I ... I agree with you, I mean, I'm only teaching one college class but I make it a point that if they give me homework one day, they get it the next because if they don't, most likely, they don't want to even look at it.

T5: Well, no. And see ... and a lot of the stuff, when I grade a test, I make comments on it...

DH: Yep.

T5: I don't spend much time going through an exam after the kids have taken it.

DH: Oh, OK.

T5: Most of the kids know by reading their tests, ya know, what needs to be fixed.

DH: Um hm.

T5: Ya know, and uh ... so I write all over the test...

DH: Yeah.

T5: And some kids really ... they might be a ... it might be a test that's written in the 90's but it's still got red all over it just because there's some direction they could have taken, ya know, and I'm really kind of set on some of the ways I expect kids to get things done ... and uh ... and then the one thing that I tell the students as well, is their semester exams are taken right off the old test.

DH: OK.

T5: Which forces them, I hope, to correct the test.

DH: Um hm.

T5: When they get them back, ya know, and it works really well.

DH: I see a lot of things your talking about because even with just the one class that I am teaching right now, I tend to write all over their homework. I don't correct every problem because I assign a certain number, but when I do correct I pick certain ones that are representative, and then I ... I will write stuff on their paper indicating where the problem areas are and so on and so forth. And like you, I probably put in, oh, a couple hours a day, um ... if I get homework, I'm spending a couple hours, where of course, in my situation, it's 40 students rather than 200 or more ... so ... it's not as big of a load.

T5: 100 would be the top one... Well see, one thing, also, see like, collecting homework, I don't collect homework. I grade homework during class, I walk through the classroom and see who's doing what, who's where...

DH: Oh, I see...

T5: Ya know, I don't collect homework.

DH: Uh huh.

T5: Because I ... I, ya know, I, like I say, grade homework during class. I walk around and see what they're doing.

DH: I see what you're talking about. That's something to keep in mind.

T5: Oh, it saves a lot of time outside the school, cuz it's like, the tests take long enough to go through, ya know. So I don't use that time grading homework assignments.

DH: Uh huh. Keep going.

T5: Try it. It's ... you'd be amazed. Ya know, I don't know if ya, if yer ... college situation, I'm real ... I taught at MSU, working on my Master's, the classes were such that you couldn't wander around the classroom, I think you had desks all the way to the back wall.

DH: Yeah.

T5: Ya know, you couldn't get ... unless you went up and down the rows.

DH: Um hm.

T5: Um ... but I just watched the kids work.

DH: The reason I ask on this is that eventually, well next year I'll be um ... teaching at a university as a professor and I'll be teaching methods courses and it's nice for me to know, uh ... what to tell these students to do, ya know, from ... from various sources that I've, ya know, various teachers that I've talked to. What works and what doesn't, because if they try to ah ... collect and correct everything, they can't do it ... there's gotta be some give somewhere and some way you can uh ... make up for that. So what you're talking about, walking around, seeing what they're doing, rather than correcting all that homework, um ... later, makes a lot of sense.

T5: Oh yeah. I look in on classes around our building and I'll see people sitting at their desks grading papers from the last class...

DH: Uh huh.

T5: Well, they should be walking around the room grading the class they're in right now.

DH: That makes sense.

T5: Ya know...

DH: Makes a lot of sense.

T5: Cuz the kids know you're there, ya know, and if they have a question ... a lot of kids won't ask a question unless you're right on their shoulder, ya know, and ya know, walk up and say, well how's ... how're ya doing? What problem are you on? How's that problem going? A lot of kids, ya know, if you do that, you're essentially inviting them, if they have a problem, to get it taken care of.

DH: Um hm.

T5: And ... there's so many students, that uh ... won't do that unless you're right there close, they won't, ya know, they won't ask in the middle of class time.

DH: Um hm.

T5: And uh ... so that's just, I don't know, that's just the way I do things.

DH: It's interesting, I ... I ... ya know, like I said earlier in the conversation, I wish I had more time to talk, ya know, I ... I've had to get through this questionnaire and so on, but it would have been nice to spend more time on things that kind of go off on a tangent because uh ... what you're saying is interesting and ... uh ... it gives alternatives to teachers that say, "I can't assess the higher order stuff, because I'm so busy correcting stuff."

T5: See, I don't buy that.

DH: And this ... you give an alternative, you do your assessment during the class time rather than correcting homework, you walk around, you see what they're doing, you don't have to correct that homework, you can spend you time with the students and then you can see what's going on with the tests.

T5: Sure.

DH: Huh. Interesting.

T5: Well, then, also, ya know, one thing that you know when you walk around the classroom, see some kids checking out a bunch of numeric answers on something, where an exact ... I ask ... most of my test questions, I leave the answer exact.

DH: Uh huh.

T5: Very few computational answers to finish out a problem, unless they need the answer for another step in the problem. So I ask for a lot of exact answers.

DH: I hope I get more of your students at whatever university, cuz I like those exact answers too.

T5: Uh ... cuz that, kind of in a lot of cases, takes the calculator out of their hand.

DH: Yeah.

T5: It kind of controls the calculator use...

DH: Yep.

T5: and uh, and if you, ya know as well as I do, exact answers are easier to read than decimal answers.

DH: Yes.

T5: Ya know, and I just enjoy that.

The rest of the conversation had no bearing on the interview and was deleted so that the teacher would remain anonymous.

## Interview Number Six

Teacher T6 has:

- a baccalaureate degree in mathematics and English
- 24 years of experience teaching in public schools,
- approximately 370 hours of SIMMS professional development, and
- computers, graphing calculators, and CBL's available for his/her students.

DH: First question. Describe the types of test questions used by your high school mathematics teachers to assess your understanding of mathematics.

T6: When I was in college?

DH: When you were in high school.

T6: Uh, it was all recall. We had no ... I went to school in the 60's.

DH: It was all what?

T6: It was all recall.

DH: OK.

T6: Basic facts, algorithms...

DH: OK, basic facts, algorithms ... I'm writing at the same time in case something happens to the tape. OK, yeah, I went to school during the 70's myself. I know what it's like, so traditional. Um. Describe the types of test questions used by your college mathematics teachers to assess your understanding of mathematics.

T6: I graduated from Montana Tech and at that time everything was very traditional.

DH: Pretty much the same as high school?

T6: Yes. I've been out of school for a long time.

DH: Yeah. I uh ... I remember the same thing. In fact when I went to college the first time I uh, worked construction several years after that, but anyway ... when I went the first time I took calc and I stopped after calc 1 and the reason is, is it was all ... it was all how to compute and I had no concept of what it meant. And I didn't dare go into calc 2 because I didn't even understand calc 1. So it wasn't til I came back to college again that I started to understand what it meant. That was ... so I understand what you mean there.

Uh, list one, two, or at most three factors that have most influenced the way that you assess your students and explain how they have influenced your assessment practices.

T6: Well I think, number 1 has to be the SIMMS training that I took for ... during the teacher leaders...

DH: Um hm.

T6: I think uh ... that has changed my teaching strategies a lot.

DH: Um hm.

T6: I was also involved in a program called IMPACT, Implementing Math Programs and Computer Technology, before the SIMMS Project, that had an impact on my teaching.

DH: Um hm.

T6: And I think, with experience, um, the more you're in the classroom the more you know the importance of teaching concepts rather than teaching facts.

DH: Um hm.

T6: And I guess those are the three things that mattered most.

DH: OK. I'm just starting to look at the data. It's kind of interesting to see uh ... how um ... years of experience are affecting the way people assess. That's one thing that I'm gonna uh ... try to get a handle on. See if uh ... years of experience does make a difference. To gain more detail about your assessment practices in the classroom, describe to me other methods than regular classroom tests that you use to assess your students understanding of mathematics?

T6: I do a lot of informal assessment. Uh ... I give daily quizzes, I mean, like five minutes in the classroom while I do my routine um ... bookkeeping ... I always have one or two problems up on the board. I think that sets the tone in my classroom, my kids settle down, they know there's gonna be a quick quiz, that's only going to take five minutes to do. Um ... I do a lot um ... oh ... integrating oh, where they respond in sentences rather than just computations.

DH: They respond in what?

T6: Sentences.

DH: Oh, OK.

T6: And they... I have kids explain in their own words what the topic for the day was about, rather than doing 500 computation problems, we do more 'explain what you've done and how you would go about solving this particular problem'. I do have a lot of kids that are main-streamed into my classroom.

DH: Um hm.

T6: So I do rely on ... a lot on traditional math...

DH: Yep.

T6: for those kids.

DH: OK. In order of importance, list which methods of assessment provide the most weight when you eventually assign a letter grade to a students performance in the classroom.

T6: Um ... I hate to say it, but tests. I ... I think I have more control...

DH: Um hm.

T6: ...on controlling that grade. I can give daily homework assignments...

DH: Um hm.

T6: I do grade them like uh ... 10 points every day and it's a completion...

DH: Um hm.

T6: ...thing, rather than an accuracy grade.

DH: Um hm.

T6: But, um ... I hate to say it but kids copy...

DH: Yeah.

T6: ...so I ... I do grade, like I would say, my tests are about 40% of the grade.

DH: Um hm.

T6: And that may be ... homework would be about 40%...

DH: Um hm.

T6: ...and their class participation, their little quizzes would make up the rest of it. I do have um ... kids do journals and um ... class participation.

DH: Um hm. OK. Coming down with a cold so I had to clear my throat here. Uh ... presently, there is discussion in the education journals of assessment of higher-order thinking skills, relative to Bloom's taxonomy, and of course, there's other scales or taxonomies, but just focusing on Bloom's. As an expert in your field, comment upon the feasibility of assessing your students at levels three through six of the taxonomy. Uh ... application, uh ... synthesis, analysis, evaluation ... those four.

T6: I test those, like one or two tests ... uh ... questions on my actual test...

DH: Um hm.

T6: But in all reality, my whole test is not geared for the upper level thinking skills.

DH: Um hm.

T6: If I had a gifted class, I'm sure that's where I would gear my tests to. But I guess my philosophy is, I have to test kids that are in my class and I have a very wide range of students.

DH: Um hm.

T6: So I would say, maybe 15-20% of my test might be geared for the upper thinking skills, but in all actuality, I'm still doing a lot of just concepts...

DH: Um hm.

T6: ...and traditional facts. Cuz we mainstreamed some of our special ed. students into our classrooms.

DH: Oh. OK. So you have to, like you said, gear towards the different, uh ... ranges of students so you don't uh ... um ... so to speak, uh ... if you have students on the lower end, you're not gonna be failing all of them because you're assessing too high.

T6: Right.

DH: OK. And I think that also kind of answers the next question, what levels of Bloom's taxonomy, do you believe that your classroom tests assess your students? So you're looking at ... um ... you're saying what percent you're thinking were up there? 15%

T6: About 15 maybe, 20.

DH: OK.

T6: I know that's not the right response but...

DH: Well, it's ... it's ... I don't know if there's such a thing as a right or wrong ... I ... I think the truth is, is that it depends on the students, it depends on the time that you have, it depends on what the students want to get out of it. There's so many variables that uh... um ... I think the literature and the research is more of an ivory tower and that's gotta be adapted to the classroom, and what you have. I mean, I teach at the college level and I know uh ... I teach ... I assess different levels depending on what classes I have to teach. So I ... I've gotta do the same thing and it ... it doesn't change in going from high school to college. It just uh ... um ... oh ... it ... it's just that the lower end classes where they're introduced, you're not so conceptual, you don't test ... you don't assess conceptual so much, and then as they get towards graduating or graduate students, then you can go for the conceptual, but it really depends on the students. So uh ... in that respect, like I said, right or wrong. Any questions? OK. That should take care of it. I've got it recorded and uh ... got some notes here and that'll help me.

T6: Are you working on your doctoral?

DH: Yes.

T6: Oh, well good luck.

DH: Yeah, I've uh ... oh... I've gathered quite a bit of the data and I ... I'm thinking I should be getting done towards May with everything and uh ... got a job lined up at Minot so...

T6: Oh, nice.

DH: But uh ... yep.

T6: Good luck.

DH: Thank you.

T6: B'bye.

DH: Yep. Bye.

## Interview Number Seven

Teacher T7 has:

- a baccalaureate degree in business
- 8 years of experience teaching in public schools,
- approximately 100 hours of SIMMS professional development, and
- computers and graphing calculators available for his/her students.

DH: ...main questions. Describe the types of test questions used by your high school mathematics teachers to assess your understanding of mathematics.

T7: Um ... see, we've gone back to more of a traditional sense because of ah ... parental pressure

DH: Um hm.

T7: Um ... so we're really not...

DH: But this is your teachers when you were in high school.

T7: Oh, my teachers?

DH: Yes, exactly.

T7: That's too long ago to remember, but basically it was uh ... rote memorization, ya know they ... they tested the regurgitation...

DH: More traditional?

T7: That's right.

DH: OK. So that would be where...

T7: There was no uh ... uh, in class, uh ... group work, ya know, there wasn't any cooperative learning.

DH: OK.

T7: Strictly instructor driven.

DH: And then, kind of, the work was computational?

T7: Right.

DH: OK. How about at the coll...

T7: Algorithms, pretty much all algorithms.

DH: OK, algorithm, gottcha. How about at the college level? Was it any different when you went to college?

T7: Not much.

DH: So there wasn't, uh ... you didn't have too many classes where they assess the higher order thinking skills at all, it's just more or less the same thing; memorization, um...

T7: The only one that might have been was proof and problem solving, but the guy was way over my head and I...

DH: I ... I see, you mean there...

T7: Not my favorite area of mathematics.

DH: OK. Then, next one is list one, two or at most three factors that have most influenced the way that you assess your students and explain how they have influenced your assessment practices.

T7: Um ... I guess I always, uh ... managed to write a test that has one or two specific areas that go beyond um ... testing the average kid, so that I can find some way to separate, ya know, the A's from the B's.

DH: Um hm.

T7: Um ... and, I mean the test that I just gave in particular from the uh math 4 SIMMS book on big business...

DH: Um hm.

T7: Um ... where we're looking for asymptotes?

DH: Um hm.

T7: Um ... there was one where they would have had to have used the uh ... table feature to find the uh ... a point of discontinuity along with the vertical asymptote...

DH: Um hm.

T7: ...only a few kids were able to find that. So I mean it's just ... I don't know how to be specific other than that. You know there's little things that you can build into a test that ... that determine ya know, how much true knowledge that the individual has grasped or comprehended.

DH: Um hm. How about as far as, is there anything in your past that has influenced your assessment practices, for example, is there a certain teacher that did something? Is there a professional development that you received? Is there things that have happened with uh ... your schooling that has determined how you will assess you students?

T7: Well, ya know, other than the traditional type testing, I mean, there are other things that ... that you utilize, such as improvement by the student, uh... uh ... you can use a ... written type of test um ... journals...

DH: Um hm.

T7: Those sorts of things. And I do use those...

DH: Um hm.

T7: ...a little bit, as alternate methods of assessment.

DH: So, would it be accurate to say that the way you were assessed in high school and college influences the way you assess now? Or, are there other factors?

T7: The other factors are the... the training that I've picked up through the uh ... uh ... SIMMS instruction.

DH: OK. And anything other than SIMMS?

T7: Um ... well uh... ya know, reading the journals and stuff.

DH: OK. Uh ... which journals, just out of curiosity?

T7: Uh...

DH: Are you talking, well, like the Mathematics Teacher and...

T7: Right, right.

DH: OK.

T7: Things like that.

DH: Gottcha. OK.

T7: Ya know, and then ya get on internet and look at stuff, and ... and see what other people are doing.

DH: Oh, I see.

T7: Ya know I might, in particular, might go to an area um, let's see, in ... where did I ... oh, like I might go into Calculus Region and look at limits and see if...

DH: Um hm.

T7: ...what other guys are doing. And I did that with some projectile motion stuff. I...

DH: Um hm.

T7: ...I went on internet and saw what I could find on that.

DH: Um hm.

T7: Ya know. Downloaded maybe some problems that other instructors utilized.

DH: That's one thing that uh ... I'm sorry to butt in on you, but it's...it's just interesting you mentioning this because I haven't heard that before. I know it's there, but I haven't heard teachers talk about that very much, that that may be influencing how they assess.

T7: Well, it helps you figure out what the other guys are doing and, ya know, maybe there are some problems they're using that maybe you could utilize for that particular unit or...

DH: Um hm.

T7: Ya know ... or it gives you an idea or notion where to go, you know, in creating your own material.

DH: Um hm.

T7: That sort of thing.

DH: That's interesting. I ... I think that's something that math educators have to be more aware of is that the internet's there and the teachers uh, may ... ya know be accessing that more and more and trying to gather uh ... different ways of assessing.

T7: Sure.

DH: OK. Interesting. To gain more detail about your assessment practices in the classroom, describe to me other methods than regular classroom tests that you use to assess your students understanding of mathematics.

T7: I'm not quite following you on that one.

DH: OK. So many teachers, we ... ya know, myself included, we use tests, we use quizzes, but are there other methods that you use to assess your students? And what are they? Other than tests and quizzes.

T7: Um ... at the beginning of the year we use the portfolio method where we generally summarize what we did in that unit.

DH: OK.

T7: Ya know, had them write terms so there's some understanding of the vocabulary...

DH: Um hm.

T7: Uh ... ya know different things, not just focusing in on that but an overall knowledge base of... of that particular unit.

DH: OK. Portfolio. And are there any, like lab assignments, or reports, or...

T7: Um ... I'm doing that with the calculus kids. I mean, there's some lab explorations that we're using for the TI92. Um ... hopefully later on, uh ... we'll be able to uh ... spend some time, use some CBL's to explore a little bit further.

DH: OK.

T7: Some of those things.

DH: OK. In order of importance, list which methods of assessment provide the most weight when you eventually assign a letter grade to a student's performance in the classroom. So what... what's most important for the letter grade?

T7: Uh ... well for me it would be the test. Ya know, but I mean,

DH: OK, um hm.

T7: Uh...

DH: And then other things, in order of importance?

T7: Yeah, uh ... such as improvement, ya know, uh ... maybe it'll come through uh ... uh ... asking questions and eliciting responses from them for particular areas, ya know...

DH: Um hm.

T7: different things like that.

DH: OK. Presently, there is discussion in the education journals of assessment of higher-order thinking skills, um ... relative to say, Bloom's taxonomy. As an expert in your field, comment upon the feasibility of assessing your students at levels three through six. Those levels are application, um ... uh ... evaluation, uh ... analysis, synthesis. What's the practicality of assessing those levels in the classroom?

T7: Well, I used to think it was high, but ya know, we got kids going to college now, and, we're getting pressure from parents that they're not prepared properly, so...

DH: Um hm.

T7: Ya know, obviously the foundation that we're giving them here isn't uh ... a strong enough base to be successful at your level, so ... ya know, I ... I see uh ... there's uh ... we need to bridge some sort of gap there.

DH: What are the problems that you encounter in trying to assess a higher level, from, ya know, assess your students at a higher level?

T7: Um...

DH: Are there difficulties with that?

T7: Yeah, kinda, I mean, I don't think there's enough, ya know, in particular, in the SIMMS material...

DH: Um hm.

T7: ...of base foundation, ya know like the calculus kids are struggling with some of the algebraic skills. Although I am taking the time to teach that along with the technology.

DH: Um hm.

T7: Ya know, when the program first came out, it was supposed to replace, ya know, some of the uh ... demands according to the NCTM standards.

DH: Um hm.

T7: Well, that's... we're not seeing that at the college level.

DH: Um hm.

T7: So, you know ... we're not on the same page.

DH: OK. So, uh ... basic skills in some cases are poor so you have to spend time working with the basic skills so they're ready, uh ... the curriculum may not uh ...

T7: And what that does, is it takes you away from some of that higher-order thinking, ya know where you can...

DH: Yep, exactly.

T7: ...and do the experimental stuff and then apply it.

DH: Um hm.

T7: I mean, you don't have the time.

DH: Yep.

T7: So ... that's a problem.

DH: Yep. And it's ... it's the same no matter who I talk to and it ... it's just uh ... there's a lot of factors involved there. I ... I don't think some people know the number of factors that are involved in trying to assess at those levels. And at the same time, make sure the kids have basic skills.

T7: Ya know, I mean, the kids are changing as time changes and all. Um ... they're expecting us to teach those algebraic skills down in the junior high level, well, ya know, they're not ... they don't have the ... the skills at that level because of all these other factors, ya know, so, the expectations that are being placed on us are not realistic.

DH: Yep. OK. I'm writing some notes here at the same time...

T7: Ya know, everything would be great in the world of utopia, but we don't live in utopia.

DH: Yep, I understand what you're talking about. And it's the same thing at the college level, I mean we deal with some of the same issues, uh ... as far as students and assessment and so on and so forth... it doesn't change very much.

T7: Well, I mean, you're gonna get uh ... class full of students that have different levels of skills.

DH: Yep, exactly.

T7: Ya know, and where do you teach? Do you teach to the middle, do you teach to the high, bring the low ones up, or...? Ya know, it's ... it's a tough judgment call.

DH: Um hm. Next question, at what levels of Bloom's taxonomy do you believe that your classroom tests assess your students?

T7: Hm ... I ... I'm not real sure.

DH: OK.

T7: Uh ... it's a combination of everything, ya know, just depends on what I'm focusing in on in that particular area.

DH: OK. Depends on the class and the students, and so on and so forth?

T7: Right.

DH: OK.

T7: Plus it depends on what I've set out as the objectives, ya know. Do I want them to be able to utilize the technology? Do I want them to have those fundamental basic skills algebraically?

DH: Um hm.

T7: Uh ... ya know, it depends on what I'm trying to focus in on.

DH: You mentioned something earlier in the conversation about um ... pressure from parents to ... uh ... for more traditional assessment? Did I read you right there?

T7: Right.

DH: Uh ... they want more, like the basics...

T7: Well, they're blaming ... they're blaming us for the kids not getting the uh ... a strong enough education at the secondary level to be successful. But see what they don't understand is...

DH: Um hm.

T7: Ya know, maybe they're not getting the true picture from Sonny or Susie at school, what they're doing.

DH: Uh huh.

T7: Uh ... and that's part of the pressure there too.

DH: Uh huh.

T7: So...

DH: Is that kinda like what happened in California with the backlash against some of the reform um ... curriculum?

T7: I would say, probably. Ya know, I mean there's a ... first of all there's gonna be a resistance to change.

DH: Yep.

T7: It doesn't matter.

DH: Yep.

T7: Um ... in our particular case, uh ... let's face it, the SIMMS textbooks do not look like a textbook...

DH: Yep.

T7: Uh ... I mean, there's lots of great things about it but there's also lots of drawbacks. So, basically what we're looking at is changing the textbook, still teaching the integrated math, uh ... in fact you can't find a traditional textbook out on the market anymore because that's not the wave of the future.

DH: Yep. I know what you're talking about.

T7: But what we're gonna have to do is find ... and what we're gonna do is buy a book that says algebra on it and geometry or whatever. Ya know, something that looks familiar to the parents and still teach modern day math.

DH: I see what you're talking about. It ... it's ... I took a class in change theory about a year or two ago and it was very interesting, all the things that you have to take into consideration if you want to make even small changes. It's ... it's ... you ... it's very difficult to move these people along.

T7: Well, and ya know, and I don't think the university has moved along like they said they were going to ... either...

DH: Oh, they haven't.

T7: Ya know. I mean that's part of our big problem because...

DH: Yep, yep.

T7: ...they were the ones that were demanding the change.

DH: Yep. Yeah.

T7: There's a big frustration at the secondary level with that...

DH: Yep.

T7: ...that particular issue.

DH: Yeah, I understand what you're talking about because there's always ... there's always this thing of finger pointing, the parents finger pointing, the secondary teachers, the college teachers, and I think ... one thing I heard recently that makes a lot of sense is you got to work with what you have and pay attention to your own area. For example...

T7: Well, and you know, and you get back to Bloom's taxonomy, really all I'm really trying to do is to create a learner.

DH: Yep.

T7: Not necessarily a mathematics learner...

DH: Yep.

T7: ...but some kid ... and give them the skills, so they'll be able to utilize all the resources that they have.

DH: Um hm.

T7: When they get to college, they'll be successful.

DH: Yep, and I think that is the new wave, so to speak, in education. Uh ... get somebody that knows how to learn, and I ... think that's what we need, ya know, same thing at the college level to emphasize the ... the ... emphasize learning more than memorizing, more than uh ... regurgitating, etc. ... etc....

T7: I mean, that's one of the reasons we use journals and the writing and all that ... ya know, just to expand. Note taking, see that was one of the good things about the SIMMS textbook is...

DH: Um hm.

T7: ...the kids had to learn how to take notes, ya know, because you taught from the notes, you tested from the notes. Ya know, like the freshmen and sophomore level, when I taught there, I let those kids use those because I wanted to appreciate that, you know, uh ... if you put effort in to study, then you'll be rewarded.

DH: Um hm. OK. Well, I'll let you get back to your stuff, but I appreciate this, this is good information. Some interesting stuff you've had in here. Thanks a lot for your time.

T7: All right.

DH: Um hm.

T7: Bye

## Interview Number Eight

Teacher T8 has:

- a master degree in educational technology
- 22 years of experience teaching in public schools,
- approximately 18 hours of SIMMS professional development, and
- computers and graphing calculators available for his/her students.

DH: Describe the types of test questions used by your high school mathematics teachers to assess your understanding of mathematics.

T8: My understanding?

DH: When you went through high school, what type of...

T8: Oh, my goodness, that was about 35 years ago.

DH: Yeah.

T8: Um ... I really don't remember, it was mainly just uh ... we practiced the concepts and then we had tests on them. I ... and I know I always did well on them, whatever they were.

DH: Was it ... what they'd consider traditional today, or...

T8: Yes, very traditional.

DH: OK. So what the homework and then the tests and then uh ... the testing being more on computational than on uh ... conceptual understanding? Or...

T8: I ... I really couldn't tell you.

DH: OK.

T8: I just ... I just couldn't tell you.

DH: But I mean, you probably don't see some of the assessment practices you see today, such as um ... students doing journals, working...

T8: Oh no.

DH: ...together in groups. OK. I think I know what you're talking about. How about at the college level? What types of test questions, uh ... assessment were used in your math classes?

T8: I remember my calculus tests. Ya know, they'd be one or two questions. And they would cover every... you had to know everything that had been covered to ... to be able to solve the problem.

DH: Um hm.

T8: There was no lead up ... you had to start from the beginning and ... uh ... and then do the work pretty much standard, I think.

DH: Uh ... um ... was it the type where you would have to figure something out as far as the computation, you had to do several steps to get to that?

T8: Oh, yes.

DH: OK. So multi-step problems.

T8: Yes.

DH: OK. List one, two or at most three factors that have most influenced the way that you assess your students and explain how they have influenced your assessment practices. Things that have made a difference on how you assess your students.

T8: Um ... first of all, I try to find out what kind of students they are. Like this year I have some calculus students that are very group oriented, and um ... sometimes they ... they prefer having the group approach, um ... it's kind of like monkey see, monkey do. There's a couple that are really very sharp, they figure it out and then the rest of them listen, or just learn what they do. Then they're very good at reproducing.

DH: Um hm.

T8: And so, I try to write my tests to uh ... um ... make sure that they've learned the process.

DH: Um hm.

T8: And that it's um ... you know, part of the test will be just reproduction...

DH: Um hm.

T8: ...but there's going to be part on the test that separates the C student from the A student, where they have to think. It's about the ... what is it? 5th or 6th level of thinking? They have to take what they have learned and then go from there. Or they can't solve the problem.

DH: OK. Now are there any things such as teachers that you've had, workshops you've taken, um ... things that you've read that have influenced how you assess your students and at what level? For example, let's say um ... some people may say that, uh ya know, when I was in high school I was tested in a traditional manner, and so therefore I tend to test in a traditional manner? Or another person may say, I was in high school, and I got tested that way, I didn't like it so I don't test my students that way. So are there certain things that have happened to you that have influenced how you assess your students?

T8: Hm ... I don't know, I ... I feel like um ... they need to know the material and sometimes the traditional way of testing tests that.

DH: Um hm.

T8: But I feel like you need to go beyond...

DH: Um hm.

T8: ...too. Then you have some students that are never gonna get beyond that, and it's pretty hard to ... to test them. Um ... I've had some teachers that I think have ... have influenced me that way. That I want to be able to assess them all, you know, in a way that's um ... is best for them, but then you also have to think about the time constraints, and what is in that.

DH: Um hm.

T8: Um ... excuse me, I'm on the library phone...

DH: Yep.

T8: ...and I need to answer it here...

DH: OK.

T8: So I'm gonna have to put you on hold for a few minutes.

DH: OK.

T8: Hello?

DH: Yep.

T8: OK.

DH: OK, lets move on then. Um ... describe to me other methods than regular classroom tests that you use to assess your students understanding of mathematics.

T8: Oh, OK, oh, I'm sorry. OK. Just let it be. Um ... could we change this? The secretary has to go and my kids are taking a test. Could I call you later?

DH: OK, when would be a good time?

T8: Um ... let me see what our schedule is here. We're at 20, 2:00 relief, we're on 7th, 11 to 11:49. I am free from 11:52 to uh ... 1:16 now.

DH: Uh ... let's see.

T8: Or...

DH: Yeah, I've ... I teach my class and I'm giving a test today.

T8: Oh dear.

DH: Um...

T8: Um ... how about uh...

DH: And then I...

T8: Tuesday or Wednesday of next week, we could finish...

DH: Let me just stop this...

The interview stopped at this point and was continued the following week.

DH: I got it going now. Let's continue on with uh ... question #4. I'll read that out.

T8: OK.

DH: To gain more detail about your assessment practices in the classroom, describe to me other methods than regular tests that you use to assess your students understanding of mathematics?

T8: Um ... well, like when I taught a new concept, I discovered that if I have uh ... I have several sample problems and I cut them out on a piece of paper so they don't think it's overwhelming...

DH: Um hm.

T8: ...and everyone gets one of those, in they ... as they do it they have to bring it up and show me.

DH: Oh, OK.

T8: And then I kinda keep track. Like I'll have three to four different questions, and it's ... it really does work.

DH: Hm.

T8: Because they learn the process. They know they have to because they've got to come and show it to me within the first 10 minutes.

DH: Hm.

T8: And it works real well.

DH: That's interesting.

T8: They're very efficient.

DH: That sounds a lot like uh ... I can't remember who the author is, but he writes about ... something about saving time in the classroom and he gets started right away, but he

will put up ...uh ... different from what you do ... he will put problems up and have the students work through it, and then check everybody's, but this is an interesting method.

T8: Um hm. Well, it's kind of variety for... for high school students. It just needs to give them a little action and ... and that way they work at their own rate, but yet I've got some pressure on them.

DH: Huh.

T8: too...

DH: OK. Any other methods?

T8: Um ... let's see. In... in groups I will have them do things. And then their, somebody from their group has to demonstrate it. Um ... sometimes I will all have them do an assignment and then give them 5 minutes to work together in groups, and then they staple those together and I go through and grade each group.

DH: OK.

T8: And that way they give each other feed back...

DH: OK.

T8: ...before I see it.

DH: In order of importance, list which methods of assessment provide the most weight when you eventually assign a letter grade to a students performance in the classroom.

T8: Um ... boy, now this is for math, isn't it?

DH: Yes, um hm.

T8: Physics, I have a lot of projects that they... I grade them on. Um ... I ... the way I do it usually, I'll just explain the process...

DH: Um hm.

T8: I give a test after every four days of instruction.

DH: Um hm.

T8: And they keep notebooks...

DH: Um hm.

T8: They have to turn in the notebooks with those four assignments and I go through... we go over any questions they have during class and, I don't correct them. What I do is I look at their notebooks to see that they've done the work, and that they've tried.

DH: Um hm.

T8: And, of course they have to have a certain number in there too.

DH: Um hm.

T8: And each one of those um ... is worth 400 points. So I have 800 points, and then I give 2 quizzes, so this is a two-week process. When I get done I add the two quizzes, each 100 points, to homework averages, or totals, each worth 400. And that's 1000 points, I divide by 10...

DH: Um hm.

T8: ...and that's one test grade. Then um ... we probably have 2 test grades over that two ... two-week period.

DH: Um hm.

T8: So it would be two weeks to one homework quiz grade.

DH: So it's kind of a combined tests, homework, quizzes, that go into deciding the grades, it's not one really dominates the other?

- T8: Oh, no.  
DH: OK ... OK.  
T8: You can't do that with ... I don't think, with high school kids.  
DH: Um hm.  
T8: You need to keep them ... oh, what is it ... uh ... I can't think of the word I want to say, but they need to be ... held accountable.  
DH: Oh, I see.  
T8: If you don't require homework, they're not gonna do it.  
DH: Yeah, I know what you mean there. Although I've seen, at times where uh ... tests, well this is probably more often I see at the college level, where everything will depend on the test and nothing else, and it's ... it's do or die...  
T8: Oh yeah.  
DH: You're right, if you don't have the homework, they don't do it.  
T8: No, and then they lose out, they just uh ... they gradually don't ... can't do things.  
DH: Yep.  
T8: It's a pain.  
DH: Well, I deal with the same thing here...  
T8: I'm sure.  
DH: Cuz I collect homework, I don't know that too many teachers here ... there's some will, some won't, uh ... will correct some of it, and I try to correct it, because if I don't, it probably won't get done.  
T8: You're right. If they've gotta have that ... they have to know that you have looked at it, ya know, one way or another, and then they'll do it.  
DH: Yeah.  
T8: The more comments I can write, the better they do it too.  
DH: Huh.  
T8: Just cuz somebody cares, I think.  
DH: Yeah, I ... I think that makes a big difference, if it just comes back with a grade, their feeling is ... is like, this person doesn't care what I do.  
T8: Right.  
DH: Huh.  
T8: Right.  
DH: Presently, there is discussion in the education journals of assessment of higher-order thinking skills, say according to Bloom's taxonomy. As an expert in your field, comment upon the feasibility of assessing your students at levels three through six of the taxonomy. In other words, how feasible is it to assess higher-order thinking skills?  
T8: Well, it depends on the level of your students. My calculus kids it's fun. I can do it. My younger kids, sometimes for ... for the kids ... if you've got a general group...  
DH: Um hm.  
T8: ...it's a struggle just to get them to learn the concepts, let alone be able to apply it.  
DH: Um hm.  
T8: Um ... I have two algebra 2 classes that are entirely different, my lowest in the class of 29 students is probably a 72%. I can do anything with them.  
DH: Um hm.

T8: But my other one, I have six failures out of 20, and they just absolutely cannot comprehend what's going on. So I have to change it.

DH: Um hm.

T8: I can't ... I can't test them on higher order.

DH: OK. And that makes sense.

T8: Ya know, you have to read your class.

DH: Um hm. Yeah, and ... and that's something that uh ... this comes out talking to several teachers, and ... and it's the same thing where I'm at. You have to look at what the students can do first.

T8: Um hm.

DH: Uh ... otherwise you may have everybody failing your class which doesn't go over well.

T8: No. For you or them or...

DH: Yep.

T8: ...your bosses.

DH: And uh, you partially answered this ... at what levels of Bloom's taxonomy do you believe that your classroom tests assess your students? Um ... what I'm talking about is, uh ... we have the lower levels which are knowledge and comprehension, and then the higher levels; application, synthesis, analysis, evaluation. Um ... what levels do you believe that you catch, generally speaking?

T8: For the higher order?

DH: Higher, yeah, yeah.

T8: OK. The ... the top three? I always go with calculus and trig, and then um ... my algebra 2 class first period, I'm experimenting with them.

DH: Um hm.

T8: And so far, I'm ... I'm working it out.

DH: Um hm.

T8: We've been studying vectors, uh ... from rectangular to polar?

DH: Um hm.

T8: And I thought, I'm gonna expand this into physics, where they have to apply it.

DH: Um hm.

T8: And its ... so far it's working.

DH: OK.

T8: But I know my other class would be totally lost with it.

DH: And with your calc and trig, you do application. Do you do other stuff too then, like uh ... um, evaluation, synthesis, uh...?

T8: Um hm.

DH: ...analysis?

T8: Um hm. I do.

DH: OK. That uh ... pretty much takes care of the interview.

T8: Um hm.

DH: And I appreciate your time.

T8: Oh, you're welcome. Sorry about the mix-up last Friday.

DH: Well, that uh ... I ... I know I was at uh ... Belgrade for a year teaching one of the classes, and I tell ya, day by day, sometimes I wouldn't know that there were short periods. I had to be told that.

T8: Yeah, it can change pretty fast on you.

DH: So ... but I do appreciate you taking the time for this.

T8: You're welcome.

DH: So, OK.

T8: Any ... any other things I can help you with, I'd be glad to.

DH: Uh ... the only other thing is if you could get those uh ... tests in the mail.

T8: Oh, I ... I did get them out.

DH: Oh.

T8: I'm sorry, I haven't written a whole lot this year, I've just used uh ... the book tests, but I do have...

DH: That's fine.

T8: ...a couple.

DH: That's fine.

T8: One is straight just memorizing, and applying and then the other I hope is a little more advanced.

DH: Good.

T8: So we'll see. All right.

DH: Thanks a lot.

T8: You're welcome. Good bye.

DH: Bye.

## Interview Number Nine

Teacher T9 has:

- a baccalaureate degree in mathematics,
- 10 years of experience teaching in public schools,
- approximately 500 hours of SIMMS professional development, and
- graphing calculators available for his/her students.

DH: First one, describe the types of test questions used by your high school mathematics teachers to assess your understanding of mathematics.

T9: Now, you mean...

DH: When you were in high school, how did they assess you?

T9: Oh, um ... just plain old math problems.

DH: Um...

T9: Um ... basic computation,

DH: OK.

T9: there was no ... there were some story problems, you know, like, if Bob went 5 miles an hour (unintelligible). Basic story problems, but that's about it.

DH: OK. Traditional?

T9: Yeah. Very traditional.

DH: How about at the college level? Did that change any?

T9: Nope.

DH: Same thing. Computational, story problems...

T9: Yep, that's it.

DH: OK. I'm just making notes in case something happens with the recorder.

T9: Oh, that's fine.

DH: And; let's see. List one, two, or at most three factors that have most influenced the way that you assess your students and explain how they have influenced your assessment practices. In other words, are there certain things that have happened to you or that you have learned, or experienced that determine how you assess your students?

T9: Um ... probably the greatest influence has been the SIMMS Project.

DH: OK.

T9: Um ... another experience would have to be building my own house.

DH: Building a house? How so?

T9: Um ... you know, with my math background, you know, I thought it would be easy...

DH: Um hm.

T9: ...to figure out how to build a house, you know, and figure out all that stuff...

DH: Um hm.

T9: Well, we were putting on the deck and my husband said I need a right angle here. And I said, oh that's easy, that's Pythagorean theorem, I can do that.

DH: Um hm.

- T9: And he said, he gave me the measurement  $12/3$ . Well, I thought it was 12 feet and 3 ... and 3 ... or 3 inches.
- DH: Um hm.
- T9: Well, he meant 12 feet and a third of a foot, so the language that people talk that are not mathematicians...
- DH: Um hm.
- T9: ...is totally different from the way we talk.
- DH: Um hm.
- T9: So that was a big eye opening experience for me to realize that...
- DH: Um hm.
- T9: ...how mathematicians talk is not how other people talk out there in the real world.
- DH: Hm.
- T9: So, I think that was a big eye opener as to, ya know, how I teach now, to realize that not everybody talks mathematically.
- DH: Does that mean then, that you kind of have to understand how your students talk mathematically outside the classroom, the context they use?
- T9: Yeah.
- DH: OK.
- T9: It really does.
- DH: OK.
- T9: My husband was not a good math student. The highest he took was Algebra 1.
- DH: Um hm.
- T9: But he works ... he's a ... works for a lumber company...
- DH: Um hm.
- T9: ...and he does all the math all day, but it's totally different than what I would do.
- DH: Hm.
- T9: And so that was a real eye opening experience for me, was building a house.
- DH: Hm. I come from a construction background, before I went back to school so, it uh ... was actually the other way around, but uh ... uh ... it is different, I mean there's some things that uh ... to me working construction, are obvious, whereas people that uh ... even people in mathematics, it's not so obvious.
- T9: And so, and I've had ... that made me realize that, ya know, I've had ... I ... I look at math now as another language...
- DH: Um hm.
- T9: ...and so we ... I teach my kids vocab, we have a vocab test every week.
- DH: Hm.
- T9: So, and that's how I look at it now, because I talk totally different from them.
- DH: Um hm. Hm.
- T9: And so I think that would be the two biggest factors that influence the way I ... I changed my teaching. I started out as traditional.
- DH: Um hm.
- T9: And then getting involved in the SIMMS Project and building a house, I've changed everything.
- DH: That's interesting.

T9: Yep.

DH: To gain more detail about your assessment practices in the classroom, describe to me other methods than regular classroom tests that you use to assess your students understanding of mathematics?

T9: Um ... we have projects once a month.

DH: OK, projects.

T9: Um ... like one of them was to figure out how ... or how long it would take and where you would place the people if you were to pass a basketball from Washington, DC to San Francisco, California.

DH: Um hm.

T9: And so they had to decide what they were ... it was all up to them. I didn't tell them anything except that, ya know, that was the directions.

DH: Um hm.

T9: ...and that was it.

DH: Hm.

T9: So we ... all my classes have a project once a month.

DH: Um hm.

T9: Um ... that is due ... I give them at the beginning of the month and they have a week ... a month to do it.

DH: Oh, OK.

T9: So that's one way I do it.

DH: Um hm.

T9: Um ... other ways, like we have vocabulary tests.

DH: OK, you mentioned that, yep.

T9: They don't like that in math.

DH: Oh, that's not math, though.

T9: No that's not math. And um ... the other thing that I do is ... we do little, what I call math modeling things in class.

DH: Um hm.

T9: Um ... like we'll spend a day working on the computer, I'll grade them on that differently than I do homework or tests.

DH: OK.

T9: That's more grading on cooperative, you know, how well do they work with each other, and if they can follow directions.

DH: OK. Um ... are there several computers in the classroom?

T9: Computers?

DH: Yeah.

T9: No.

DH: OK.

T9: I have five.

DH: OK.

T9: Um ... they're not working yet, but they're in there.

DH: OK.

T9: They haven't hooked them up yet.

DH: Oh. Those are new?

T9: No, they're old um ... LE's. MacIntosh classic LE's.

DH: Oh my gosh.

T9: Yeah.

DH: Huh. OK, in order of importance, list which methods of assessment provide the most weight when you eventually assign a letter grade to a student's performance in the class.

T9: I would have to say um ... the projects...

DH: Are first?

T9: Projects and tests are about even.

DH: OK.

T9: And I just ... what I do is I just grade on total points.

DH: OK.

T9: So there is, you know, a test ... a quiz might be 30 points here, a project might be 50 points here, a test might be 100.

DH: Um hm.

T9: Um ... something that we do in class might be 25 points.

DH: Um hm.

T9: So there's nothing weighs more than anything else.

DH: Gottcha.

T9: Just a total of how many points we have. And we usually end up around with 1300 - 1500 points a semester.

DH: And then the vocabulary and the math modeling are kind of secondary?

T9: Um...

DH: Or do you just look at those as more points to the total points?

T9: Just add those points to the total points. Um ... they just had a vocab test this last week that was worth 83 points.

DH: Mm...

T9: So, sometimes they're worth a lot, sometimes they're not, depending on what chapter, what we're covering in the chapter.

DH: So this kind of changes with how important each aspect is, they, sometimes projects are more important, maybe other times vocabulary is.

T9: Right. Like this chapter was a lot on statistics and probability, so there was a lot of vocab in that chapter.

DH: OK.

T9: So we ... we really concentrated on what is ... what does each thing mean.

DH: OK.

T9: More than, probably the math in that chapter.

DH: And do you have uh ... quizzes in class? Other than, I mean, your regular quiz, um ... for example, maybe computational or uh ... quizzes that may be open-ended questions, or things like that, or?

T9: Um ... the open-end stuff I try to do um ... not really as a quiz...

DH: Um hm.

T9: ...but as, like, um ... we have M&M projects that we do. And they'll do that in class, then they have to broad ... they have ... at the end they have to write a summary of what happens, what they observed and stuff.

DH: OK.

T9: But I don't really try to do it on a quiz. Um ... a lot of my kids in my algebra prep classes are IEP kids.

DH: What's IEP?

T9: That means that they're special ed.

DH: OK.

T9: And so, if I do stuff like that I try to do it in class so I can read the questions for them.

DH: Oh, OK.

T9: So they can understand what I'm saying; write it in different words.

DH: Um hm.

T9: I'm not really the inclusion teacher, but I do have a lot of those kids in my classes.

DH: Um hm.

T9: So...

DH: OK.

T9: I don't try to do it on tests but I do do it in the classroom.

DH: OK. Um ... now this one I'm gonna read to you, but I may have to rephrase it. Uh, presently, there is discussion in the education journals of assessment of higher-order thinking skills, relative to Bloom, and I don't know if you're real familiar with Bloom, but uh ... um ... higher-level is such things as application, um ... analysis, synthesis, evaluation; and as an expert in your field, comment upon the feasibility of assessing your students at the higher levels of Bloom's taxonomy.

T9: Um ... I don't ... I really don't do it in my algebra prep classes. I have three algebra prep classes.

DH: Um hm.

T9: And those are the kids who came out of 8th grade with C's and D's in math.

DH: Hm.

T9: And so, what I try to do is try to get them to learn the vocabulary that goes along with it.

DH: Gottcha.

T9: And then, I teach an intermediate math class, which is for those kids who got C's and D's in algebra 1, before they go on to geometry. And again, what I try to do there is teach them the vocab so they understand what they're reading.

DH: Um hm.

T9: But in algebra 1 I do more of the higher-order um ... stuff than I do in the other classes. And I only have one class of that.

DH: Um hm.

T9: And that's probably my favorite class.

DH: Um hm.

T9: Because I can ask them, you know, um ... like we just finished doing the family of functions.

DH: Um hm.

T9: And I asked them ... we graphed a linear equation and I moved it up the X axis and moved it down, then flipped it over, and then I asked them to analyze, you know, what happens when you add something, you multiply something, and I can do that in an algebra I class.

DH: Um hm.

T9: And I would have to say that when I do that stuff, I think that's when the kids really get involved in the math and really think, but it's hard to do it in those other classes.

DH: And that's because you have to deal with the kids as they come in and where they're at and some of them are not at that place so you have to deal with them ... I ... I understand that.

T9: Yeah.

DH: And that makes all the sense in the world.

T9: Yeah, and I ... last year when I had geometry...

DH: Um hm.

T9: ...it was great because we did that all the time, because geometry is the place to do it.

DH: Um hm.

T9: Because there's a lot of, you know, analyze why this is ... you know, why does side, side, side work, or why does angle, side, angle work.

DH: Um hm.

T9: Where, you know in algebra prep, I mean, I do a lot of adding, subtracting, multiplying, dividing.

DH: Um hm.

T9: Which is basic review again, with a little algebra stuck in.

DH: Um hm.

T9: And there's no really, I mean, I don't think those kids could analyze anything.

DH: Yep, I understand what you're talking about.

T9: So I have one class where I do it and that's my favorite class.

DH: Um hm.

T9: Ya know, the other ones I don't think, my kids could do it.

DH: Um hm.

T9: Not that I wouldn't love to try it.

DH: Um hm.

T9: But there's such a range of ... of ability.

DH: Um hm. I know what you're talking about. Uh ... I teach at the college level, I get a class per semester, while I'm going to school, and some classes ... some of the students, I can push them. Other classes, and especially this semester, I've got a calculus for those that'll never ... ya know it's ... it's the last class they'll ever take. It's an introduction to calc, they'll never use calculus, and it's basically, um ... how to do the computations. And if they could even learn what it means besides that, boy I'm thrilled.

T9: Yeah.

DH: And I know what you're talking about.

T9: Um hm.

DH: Huh.

T9: So ... and then next year I get an algebra 1 inclusion class, so I don't know how I... what I'll do in that one.

DH: Um hm.

T9: I'm ... there'll be another ... there'll be another teacher in there with me who's a special ed. teacher.

DH: Oh.

T9: Um ... they said half of my class will be special ed. kids and the other half will be regular kids.

DH: Hm.

T9: So, I don't know how that's gonna work.

DH: That's ... I was just gonna ask you, how is that gonna work with that mixture, it's gonna be tough.

T9: I ... I don't know. Um ... the other teacher, I'm hoping, when I ask those kids to analyze what is happening or predict what'll happen if you do it to a cubic or a quadratic, I'm hoping that he can translate that to them in different words, where, I don't know what other word I would use.

DH: Um hm.

T9: Ya know, with the normal algebra 1 kids that you get, if you say "predict," they can do it.

DH: Um hm.

T9: Or you say, "analyze" and you know, give them a hint, and "oh yeah, now I know what you mean," but I don't know about those special ed. kids. I don't know what ... I mean I don't know how ... what I'll have to do to change, or what I'll have to do. It's going to be interesting.

DH: Um hm. Like building a house.

T9: Yes, it's gonna be like building a house. Talking two different languages again.

DH: Uh, those pretty much take care of the questions I have to ask. The packet you get in the mail, you'll probably get that in the next day or two, I ... I sent it out...

T9: I would expect tomorrow.

DH: Yeah, and what's in there is I've got a return envelope, and what I'm asking you to do is to pick three different tests that you've used in your classrooms and send them to me, and indicate the level of students, and then if there's any questions that you consider higher-level, put a circle around the number of the question.

T9: OK.

DH: And that's ... that's all there is. I threw in a Bloom's taxonomy thing for um ... when I was asking the questions, and a list of the questions, which you've already been asked uh ... so you'll get that in a couple of days.

T9: OK.

DH: But I appreciate you helping me out on this.

T9: Oh, no problem.

DH: Good information here.

The rest of the conversation had no bearing on the interview and was deleted so that the teacher would remain anonymous.

## Interview Number Ten

Teacher T10 has:

- a baccalaureate degree in electrical engineering and teaching certification for both mathematics and physics,
- 5 years of experience teaching in public schools;
- approximately 20 hours of SIMMS professional development, and
- graphing calculators and one computer available for his/her students.

DH: First question, describe the types of test questions used by your high school mathematics teachers to assess your understanding of mathematics.

T10: Yeah, I would say that, in general, that most testing questions are very textbook-type questions. So most of them I would say, are probably, ya know, looking at uh ... ya know, true and false type questioning to under ... to get a measure of knowledge of basic facts. Uh ... comprehension, especially in the algebra 1, algebra 2's where you're looking at um ... uh ... ya know, translating verbal problems into equations and expressions...

DH: OK.

T10: And then, I ... the geometry, that was still just very typical textbook-type questions.

DH: The two-column proof?

T10: Yes. They do do two-column proofs.

DH: And that's when you went to school?

T10: When I ... Oh when I went to school?

DH: Yeah.

T10: No, actually, that's ... that's ... pretty well too. I thought you were talking about here at our high school.

DH: Yeah. I ... I...

T10: Yeah, when I went... when I went to school it was very, I mean, 100% textbook oriented. In fact most of the tests were from the textbook.

DH: Um hm.

T10: And we did very formal two-column proofs. Very, very formal geometry setting.

DH: OK. How about when you went to college, did that change any?

T10: Uh ... no, it did not. The... in the math courses, it didn't change, I'd say very little. I mean very little of it was trying to, um ... you know assess understanding by, you know, having you use higher-level thinking skills. Most of it was very much related to the textbook.

DH: OK.

T10: And uh ... ya know, engineering type, which I don't know if you're interested in at all... it was actually quite the opposite, where everything was more application-based.

DH: Oh, OK, so you ... when you got into your engineering classes, then you got into the applications.

T10: That's correct.

DH: Let me write a note on that. I don't think that changes much, uh ... I teach some of the math classes, well I teach one per semester here while I'm going to school, and uh ... you get the engineers in there and they're looking to get to the applications and...

T10: Oh, absolutely. I mean, that's really why they go into it.

DH: Yeah. And that's understandable.

T10: Yep.

DH: List one, two, or at most three factors that have most influenced the way that you assess your students and explain how uh ... those factors have influenced your assessment practices.

T10: I ... I would say the number 1 thing that has influenced my ... the method that I use for assessment is probably my engineering background. Where I see the ... you know, the greater need for students um ... needing to understand more than just, ya know, being able to duplicate steps. And that's probably the #1 thing that's influenced me. Um ... the other thing, let's see, I guess another thing that does influence, which is unfortunate, is the need for students to be prepared for, ya know, entrance types of exams and college placement exams and, ya know, SAT's/ACT's. Because that, again, that gets back more to a very typical, ya know, a lot of them typical textbook-type questioning.

DH: Um hm.

T10: Ya know, those are the things that I ... I probably consider most when I'm reviewing and rewriting a test.

DH: So, with your engineering background, does that mean you try to use more uh ... applied problems?

T10: I like to but, you know, again, there just the time constraints, I don't go nearly as much of that as I would like.

DH: Um hm.

T10: But when I do have the opportunity to, that is exactly what I try to do, is try to apply it, ya know, or just go for a little deeper understanding of the concept of the material. Ya know, it's not just going through, and it won't be something that the students can just go through since they've memorized the steps involved, they can then solve it.

DH: OK. To gain more detail about your assessment practices in the classroom, describe to me other methods than regular classroom tests that you use to assess your students understanding of mathematics?

T10: Uh ... what I've been doing there, and again, it's very much a time constraint because I've been trying to get into more the alternative, you know, performance-type assessments.

DH: Um hm.

T10: And I've started that at the lowest class level I teach, which is pre-algebra, only because it's one of the easiest ones to implement it in. And um ... I don't do nearly as much of that as I'd like to. The other thing I do to really assess their understanding is I really ... I teach by walking around, and do a lot of stuff one-on-one with the students. Ya know, getting feedback as they're going through. Monitoring and seeing if they're making errors with their steps and having them justify why, ya know, just verbally ...

DH: Um hm.

T10: For a lot of the, I'd say, for the assessment of understanding, I try to do most of that before I get to the actual testing.

DH: Mm. OK. The performance assessment that you're talking about, um ... how ... how do you mean that? Can you um ... give me an example?

T10: Oh, let's see, like um ... let's say you're talking about um ... least common multiples and greatest common factors, there's one that I've pulled from a text that requires the kids to generate a formation for a marching band.

DH: Um hm.

T10: And it just goes to the understanding as to, well, can you have this ... this size, and have them explain why you cannot, and then have them go through and demonstrate what sizes would work.

DH: Um hm.

T10: And, so that's just, ya know, a typical example there. Applying it to something real, that the kids have to be able ... you don't tell them anything about the greatest common factor or least common multiples and they just have to kind of imply it from what we're going through.

DH: Oh, so you ... you've covered something with the...

T10: With the material...

DH: And then you...

T10: ...then I give them a...

DH: ...give them something where they've got to uh ... kind of transfer some of their knowledge.

T10: Exactly.

DH: OK. In order of importance, list which methods of assessment provide the most weight when you eventually assign a letter grade to a student's performance in the classroom.

T10: Uh ... #1 is just your standard classroom testing.

DH: Um hm.

T10: Um ... then I do, just what I call short quizzes in the class. And then the least amount of weight is placed on the homework in the classroom.

DH: OK.

T10: Actually homework and class participation.

DH: OK. Let's go on from there: Presently, there is discussion in education journals of assessment of higher order thinking skills, relative to Bloom's taxonomy, I know there's other taxonomies, but uh ... this is a familiar one. As an expert in your field, comment upon the feasibility of assessing your students at levels three through six of the taxonomy, application, synthesis, analysis, evaluation.

T10: Now, I ... I would say that's uh ... going through, if we just go step through that, I would say that the easiest one to assess at is application. And I think as we get into the higher math, ya know, like the uh ... trigonometry and precalculus, a lot of it is gener ... more generating a lot more application in the classroom. Just naturally. Um ... a lot of the lower level classes, there's kind of a, in a way, a catch 22, which I kind of referred to a little earlier, is that where you have to prepare the kids to be able to, ya know, take the

proper placement tests, so they have to have some of the basics. A lot of the basics are really forcing us back into the knowledge and probably more of the comprehension level.

DH: Um hm.

T10: And that's the biggest stumbling block, with getting to the higher levels in some of the lower classes.

DH: Um hm.

T10: And the other thing that I see there is just the time involved...

DH: Um hm.

T10: ...in going above application, it is very time consuming as a classroom teacher to um ... generate what I would feel are good classroom assessments.

DH: Um hm.

T10: That can test at those levels. And ya know, I've found very little, especially if you adopt text series and stuff, that there's very little there that help support those higher level thinking skills.

DH: Um hm.

T10: I'd say that, ya know, just as the feasibility of it, I think the application level is very feasible.

DH: Um hm.

T10: I think um ..., analysis, we do some of that when um ... with the graphing technology.

DH: Um hm.

T10: Where we're looking at trying to form generalizations, or trying to use the patterns or uh ... what we are viewing on the screen to try to draw our conclusions.

DH: Um hm.

T10: And I'd say that that's probably the ... one of the best tools that is ... ya know, available at our fingertips that we can use in the classroom to get up to the higher level. Uh ... the synthesis and the evaluation, um ... boy, I ... haven't even put enough thought into those ones, as to where we can apply them.

DH: Those are all tough, the higher level ones are...

T10: Yeah, they are, they really are...

DH: That's interesting, your remark about using the graphing capabilities for analysis, I mean, uh ... I know it's been out there, but I never really thought of that that way, that you know, they don't have to draw by hand, graph after graph after graph, it's so readily available, that yeah, it does become an analysis tool.

T10: Right, you can sit there and put ... like I just got done doing one with quadratic functions that are going through, here's your function, here's what it looks like, we do it totally the opposite, where we start graphing things and they actually draw all the conclusions out of it and come up with their whole set of notes based on it.

DH: Hm.

T10: And that's more of ... that's the way I like to approach the thinking skills. Again, it's not with my assessment, per se, as a test, but it's something I like to draw into the regular classroom.

DH: Um hm. And, you know, I've found that, asking this question several times, it's pretty much answered by #6, but at what levels of Bloom's taxonomy do you believe that your classroom tests assess your students?

T10: Yeah, and I'd say again that the lower classes, pre-algebra, algebra 1 and somewhat algebra 2, that those are the ones I teach, it's probably knowledge, mostly comprehension, and then we do get into some applications. In the geometry class we will get into, ya know, the formal proofs, which I believe would put you at analysis...

DH: Yeah.

T10: And they ... um ... ya know, probably that has been more de-emphasized in recent times, a lot of it because of uh... actually I guess the questioning in the math field too as to how much time we should spend on the proofs. And um ... then into the advanced math, precalculus, I spent a lot of time with the application-based things.

DH: Um hm. Let me just write some notes here. I'm just kind of curious, what textbook do you use for geometry?

T10: Right now we're using uh ... Houghton Mifflin, the um ... it's out of their Algebra 1, algebra 2, geometry series, that's the one written by uh ... Brown and Dolciani.

DH: OK.

T10: And we are gonna be changing that here, we just adopted a new series which is going to be um ... Glenco.

DH: What's the name ... do you know what the name is on that or...?

T10: No, I don't have that right here.

DH: That's fine.

T10: Yeah.

DH: I was just kind of curious...

T10: It's their new text series.

DH; You'd mentioned the changes going on as far as geometry, and the de-emphasis of proof, and I've noticed a few schools around the Bozeman area uh ... going over to Geometry, An Inductive Approach, I believe it is? I don't know if you...

T10: Is that the one by the Houghton Mifflin? Or actually I think a number of publishers have one they call the inductive approach.

DH: Um ... I'm trying to think of who um ... boy ... I'm trying ... I'm trying to associate the name with some ... Who does Geo Sketchpad? What's the company?

T10: That's um ... Creative Publications...

DH: I think, that might be the one, I may be wrong.

T10: I'm trying to remember the name of that. And it is an inductive approach.

DH: and...

T10: and ... yeah we even looked at that text.

DH: Um hm.

T10: We just decided to just keep the consistency with our math series to keep it all the same.

DH: The reason I mentioned that is that uh ... they de-emphasize proof at the beginning and bring it more towards the end, because of teachers concerns about students getting turned off by proof.

T10: Right. And then ... I've done some ... I can't remember where I read an article about that, but it's totally opposing that view. Because of the um ... teacher actually did a study and found that they were ... students were very frustrated when they got the proof at the end.

DH: Oh, that's interesting.

T10: Yeah. And I ... I can't remember where I read that, I just remember going through that. And I can see that. When I student taught they were using that text series in Livingston.

DH: Oh.

T10: And um ... ya know just watching the kids and stuff, I could really see where all of a sudden you dump the proof on them it would be very frustrating. However, the higher level thinking skills with the problems in there were wonderful.

DH: That's interesting. I think it was Livingston, where I saw that being used and that was last year, and I don't know if they still have it this year, and I believe, uh ...

Belgrade was going to switch over to that, and it's just ... I ... I have the math background and I don't mind the proof, but...

T10: Right, I don't either.

DH: At the same time, it's the student's we're working with, and, and knowing how to deal with them.

T10: Exactly right.

DH: Well, this is interesting, uh ... I appreciate your time.

T10: You're welcome.

DH: The only other thing, if you could, I don't know if you've already sent it in, but uh ... some samples of tests you have used in your classroom.

T10: Right, I haven't that yet. And do you want that from a variety of classroom, or does it matter, or...

DH: Just give me um ... three different tests. If you want to pick, pick your classrooms you want to take them from, and then if there's higher order uh ... questions on there, indicate which ones.

T10: OK.

DH: Um ... a mix is fine, or if you want to take them from the same class, that's fine too.

T10: All right, that sounds very good.

DH: OK?

T10: All right.

DH: Thanks for your time.

T10: You bet.

DH: Bye.

T10: Good bye.

APPENDIX E  
DATA FROM THE INTERVIEWS

Below is a summary of the information gathered from the ten interviews and copies of tests sent by the respective teachers. Please reference the questions in Chapter 2.

### **Teacher T1**

#### **I. Background**

Teacher T1 has

- a baccalaureate degree in mathematics,
- seven years of teaching experience in public schools,
- approximately 440 hours of SIMMS professional development, and
- both computers and graphing calculators available for her students.

#### **II. Interview**

##### **A. Question One**

1. Paper and pencil
2. Computational
3. Story problems

##### **B. Question Two - Same as Question One**

##### **C. Question Three**

1. Students' ability as test-takers
2. Relevance of the math in their daily lives

##### **D. Question Four**

1. Projects

2. Presentations
3. Group work
4. Open-ended questions
5. Research papers

E. Question Five - They are all given equal weight

F. Question Six - Student motivation is a problem

G. Question Seven - The teacher was not sure

III. Classroom Tests - Teacher 1 sent back three tests and one classroom project

#### **Teacher T2**

##### I. Background

Teacher T2 has

- a master degree in mathematics,
- thirty-seven years of teaching experience in public schools,
- approximately 20 hours of SIMMS professional development, and
- both computers and graphing calculators available for his students.

##### II. Interview

###### A. Question One

1. Story problems
2. Solving equations
3. Short-answer questions
4. Completion
5. Multiple choice

## B. Question Two

1. Solving problems and equations
2. Short answer
3. Multiple choice

## C. Question Three - Mastering basic skills

## D. Question Four

1. Homework
2. Classroom discussion

## E. Question Five

1. Tests
2. Quizzes
3. Daily work

## F. Question Six

1. Application is very important
2. Assessment depends on the class (students) and the textbook
3. Use of "factory-made" tests

## G. Question Seven - Levels two through six (depending on the students)

## III. Classroom Tests - Teacher 2 sent back three tests

**Teacher T3**

## I. Background

Teacher T3 has

- a baccalaureate degree in mathematics,

- twenty-five years of teaching experience in public schools,
- approximately 60 hours of SIMMS professional development, and
- both computers and graphing calculators available for her students.

## II. Interview

### A. Question One

1. Factoring
2. A lot of computation

### B. Question Two - Same as Question One

### C. Question Three

1. Introduction to "discovery learning" by a superintendent
2. The SIMMS Project

### D. Question Four

1. Reports
2. Research projects
3. Group participation

### E. Question Five

1. Tests, quizzes, and research projects combined
2. Reports
3. Group participation

### F. Question Six - To assess higher-order thinking (HOT) skills, lower-order thinking (LOT) skills must receive less emphasis

### G. Question Seven - HOT skills get assessed more than do LOT skills

### III. Classroom Tests - None were received from this teacher

#### Teacher T4

##### I. Background

Teacher T4 has

- a master degree in mathematics,
- fifteen years of teaching experience in public schools,
- approximately 480 hours of SIMMS professional development, and
- computers, internet, and graphing calculators available for his students.

##### II. Interview

###### A. Question One

1. Traditional assessment
2. True/False
3. Multiple choice
4. Fill in the blank
5. Free response

###### B. Question Two - Mostly traditional; some innovative

###### C. Question Three

1. SIMMS Teacher/Leader training
2. Ideas from journals and conferences
3. Teacher's own experience of being assessed in a traditional manner

###### D. Question Four

1. Classroom teacher/student interaction

2. Direct questioning
3. Quizzes and homework
4. Term papers
5. Presentation

E. Question Five

1. Tests and homework
2. Projects and quizzes

F. Question Six

1. Assessment of HOT skills is time-intensive
2. Student load interferes with the assessment of HOT skills

G. Question Seven - The teacher tends to assess at the Application level

III. Classroom Tests - Teacher 4 sent back three tests

**Teacher T5**

I. Background

Teacher T5 has

- a master degree in mathematics,
- twenty-eight years of teaching experience in public schools,
- approximately 400 hours of SIMMS professional development, and
- both computers and graphing calculators available for his students.

II. Interview

A. Question One

1. Traditional assessment

2. Rote learning

B. Question Two

1. Proof oriented
2. Graduate school required the critique and extension of mathematics journal articles
3. One mathematics educator extended the regular curriculum

C. Question Three

1. The SIMMS Project
2. Involvement in the creation of the Advanced Placement Calculus exams

D. Question Four

1. Student-teacher dialogue
2. Having students read mathematics during class
3. Observations

E. Question Five - Weighs exams and quizzes most heavily

F. Question Six - The teacher's response did not answer this question

G. Question Seven - Tends to assess all levels, but focuses on Application

III. Classroom Tests - Teacher 5 sent back three tests

**Teacher T6**

I. Background

Teacher T6 has

- a baccalaureate degree in mathematics,

- twenty-four years of teaching experience in public schools,
- approximately 370 hours of SIMMS professional development, and
- computers, graphing calculators, and CBL's available for her students.

## II. Interview

### A. Question One

1. Basic facts
2. Algorithms

### B. Question Two - Tradition; similar to Question One

### C. Question Three

1. SIMMS professional development
2. Implementing Math Programs and Computer Technology (IMPACT)
3. Experience from teaching

### D. Question Four

1. Daily quizzes
2. Journals
3. Class participation

### E. Question Five

1. Tests and homework
2. Class participation, quizzes, and journals

### F. Question Six - students in the classroom have a wide range of skills

### G. Question Seven

1. Teacher's tests are not geared towards HOT skills

2. Approximately 15 to 20% of the test questions assess HOT skills

### III. Classroom Tests - Teacher 6 sent back two tests

#### Teacher T7

##### I. Background

Teacher T7 has

- a baccalaureate degree in mathematics,
- eight years of teaching experience in public schools,
- approximately 100 hours of SIMMS professional development, and
- both computers and graphing calculators available for his students.

##### II. Interview

###### A. Question One

1. Rote learning
2. Computational
3. Algorithms

###### B. Question Two - Same as Question One

###### C. Question Three

1. SIMMS professional development
2. Teacher journals
3. Internet

###### D. Question Four

1. Portfolios
2. Lab explorations

## E. Question Five

1. Tests
2. Student improvement

## F. Question Six

1. Pressure from parents to teach basic skills (resistance to change)
2. Student's basic skills (e.g. algebraic skills) are poor
3. Expectations are changing (NCTM Standards)
4. Student's have diverse skills
5. There's not time to assess HOT skills

## G. Question Seven - The teacher was not sure

## III. Classroom Tests - None were received from this teacher

**Teacher T8**

## I. Background

Teacher T8 has

- a master degree in mathematics,
- twenty-two years of teaching experience in public schools,
- approximately 18 hours of SIMMS professional development, and
- both computers and graphing calculators available for her students.

## II. Interview

- A. Question One - Traditional
- B. Question Two - Multiple-step problems
- C. Question Three

1. Students must learn the processes they were taught
2. The way the teacher was assessed by her teachers

D. Question Four

1. Students work through problems and immediately hand them in
2. Group work

E. Question Five - A combination of tests, homework, quizzes

F. Question Six - The levels that are assessed depend upon the ability of the students

G. Question Seven - For students with high aptitude, the teacher assesses all levels

III. Classroom Tests - Teacher 8 sent back three tests

**Teacher T9**

I. Background

Teacher T9 has

- a baccalaureate degree in mathematics,
- ten years of teaching experience in public schools,
- approximately 500 hours of SIMMS professional development, and
- graphing calculators available for her students.

II. Interview

A. Question One

1. Traditional mathematics problems
2. Story problems

B. Question Two - Computational, similar to Question One

C. Question Three

1. SIMMS Project
2. Building his/her own house - the vocabulary of non-mathematicians is different from mathematicians (mathematics is a different language)

D. Question Four

1. Mathematics projects
2. Mathematics vocabulary tests
3. Computer work
4. Cooperation in a group

E. Question Five

1. Projects, tests, quizzes
2. Mathematics vocabulary and computer work

F. Question Six - The levels that are assessed depend upon the aptitude of the students

G. Question Seven - That depends upon the aptitude of the students

III. Classroom Tests - None were received from this teacher

### **Teacher T10**

I. Background

Teacher T10 has

- a baccalaureate degree in electrical engineering and teaching certification for both mathematics and physics

- five years of teaching experience in public schools,
- approximately 20 hours of SIMMS professional development, and
- graphing calculators and one computer available for his students.

## II. Interview

### A. Question One

1. Textbook tests
2. Two-column proofs in geometry

### B. Question Two

1. Same as Question One for mathematics classes
2. Engineering classes assessed applications

### C. Question Three

1. Engineering background
2. The type of assessment found in the SAT/ACT exams

### D. Question Four

1. One-to-one interaction with the students
2. Performance assessment (real-world application problems that require the transference of learned skills)

### E. Question Five

1. Tests
2. Quizzes
3. Homework and class participation

### F. Question Six

1. College placement tests have a large influence upon what gets assessed  
(a large number of "basic skills" are emphasized)
2. Writing questions that assess HOT skills is time consuming
3. Textbook tests do not assess HOT skills
4. It is feasible to test at the level of Application

G. Question Seven - the levels that get assessed depend upon the material being taught

III. Classroom Tests - None were received from this teacher

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