An investigation of the validity of the computer program "Domains of Mathematical Teaching" as a tool to examine teachers' instructional practices

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A Thesis

in

The Department

of

Education

Presented in Partial Fulfillment of the Requirements
for the degree of Master of Arts (Child Study) at
Concordia University
Montreal, Quebec, Canada

September 2011

CONCORDIA UNIVERSITY
School of Graduate Studies

This is to certify that the thesis prepared

By: Wendy Ing

Entitled: An investigation of the validity of the computer program "Domains of Mathematical Teaching" as a tool to examine teachers' instructional practices

and submitted in partial fulfillment of the requirements for the degree of

Master of Arts (Child Study)

complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Abstract

An investigation of the validity of the computer program "Domains of Mathematical Teaching" as a tool to examine teachers' instructional practices

Wendy Ing

The study's objective was to collect evidence that would lend support to the validity of the *Domains of Mathematical Teaching* (DMT) software tool for observing teacher practices in the elementary mathematics classroom. Specifically, one teacher's practice in her mathematics classroom was examined using two methods of observation: the DMT and video recordings. Percent frequencies derived from data from the two observation methods were compared in four DMT categories: Teacher Elicitations, Direct Instruction, Context of Teacher's Task Presentation, and Classroom Organization. Further, the two sets of data were used to create two teaching profiles, called Procedural and Reform, which were based on Baroody's (2003) framework depicting mathematics instruction. The profiles were created using three teacher practice measures – Focus, Methods, and Classroom Organization – and the two methods of observation were compared to investigate the extent to which the DMT reflects video analyses.

Results indicated that the DMT and video were strongly positively correlated for three of the four targeted DMT categories ($p < .01$). Moreover, the DMT generated a similar profile of instructional practice as the video recordings in each of the three teacher practice measures. Taken together, the findings provide strong support that the DMT may be used instead of video recordings to obtain data on teacher practices in the elementary mathematics classroom.

Acknowledgements

I want to thank everyone who helped and inspired me on the long, challenging, but ultimately rewarding journey to completing this work. First and foremost, I would like to express my deep and sincere gratitude to my supervisor, Dr. Helena Osana, whose expertise, dedication, encouragement, and patience made this project possible. My sincere thanks also go to my committee members, Dr. Nina Howe and Dr. Ann-Louise Davidson, for their constructive feedback and assistance. I am indebted to the participating teacher and her wonderful students for welcoming me into their classroom. I am also grateful to Vanessa Rayner and Diana Royea for helping me with data collection and coding. Lastly, I wish to thank my parents, family, friends, and Chris for their love and support.

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Statement of the Problem

Since the second half of the 20th century, researchers in mathematics education have been interested in studying the role of mathematics teachers in student learning (Mewborn, 2001). While the initial scrutiny was on teachers' credentials, the field moved on to examining teachers' mathematical content knowledge, then to their pedagogical content knowledge (Shulman, 1987). Also a current focus of research is on investigating teachers' instructional practices in the classroom (Ball, Lubienski, & Mewborn, 2001).

Improvement in student learning and achievement in mathematics is needed (National Assessment of Educational Progress [NAEP], 2005), and one way to achieve this is to improve mathematics teaching so that students learn with understanding. It is important to examine teacher practice in order to understand the role it plays in student learning. Accurate and valid instruments to measure teacher practice, however, are required to reveal what is actually occurring in the classroom.

Researchers have studied teaching practices using various methods, including asking teachers to complete surveys and logs of their teaching (e.g., Ball & Rowan, 2004). Researchers have also gone into the classroom to observe lessons and have recorded data using numerous methods such as field notes (e.g., Beswick, 2007) and time sampling (e.g., Herbel-Eisenmann, Lubienski, & Id-Deen, 2006).

Video recording mathematics classrooms has become a common method of studying teachers' pedagogical practices. Based on their experience overseeing the Trends in International Mathematics and Science Study (TIMSS) (Hiebert et al., 2003), which applied videotape methodology to a large-scale international survey of classroom instructional practices in mathematics and science, Jacobs, Hollingsworth, and Givvin

(2007) described some methodological lessons that they learned about collecting video data as well as potential pitfalls that may arise. For example, while developing a videotaping protocol will help determine what is filmed, it also limits the amount of information that is gathered. Consequently, collecting sufficient supporting data is necessary in order to understand events on video. Additionally, researchers must provide videographers with a detailed, standardized training manual to determine what activity is filmed. Moreover, videographers need multiple practice opportunities and recurring feedback on the quality of their work. It is also essential for researchers to collect release forms from the participants who are filmed. If the written permission is insufficiently broad, researchers must go back to the participants to gain their consent to use the video in less restricted contexts. Participants may also choose to revoke their permission.

While the data analysis of video recordings can be rich and varied, it requires substantial time, labor, and financial resources to carry out. Moreover, as Erickson (2006) notes, "information derived from video, in itself, does not give us direct, unmediated access to the facts" (p. 179). Videotaping is also an invasive technique and discomfort with the idea of being filmed may discourage teachers from participating in studies that entail video recording. Additionally, researchers must invest in technological devices to collect and store the data, and videographers require thorough training to capture the appropriate footage (Jacobs et al., 2007). Once the data are gathered, there is the long process of analyzing the profusion of data, which involves substantial budgets and manpower to complete in a timely manner.

To overcome these issues, Osana, Lacroix, Rayner, Pitsolantis, and Ing (2008) developed a computer-based software program called *Domains of Mathematical*

Teaching (DMT) as a time sampling tool to examine mathematics instructional practice. Trained coders observe the mathematics classroom for 10-second intervals, focusing primarily on the teacher as well as students who are interacting directly with the teacher, and using the DMT on a laptop computer, they select codes based on the options provided by the software as a series of screens appear on the computer. The DMT features categories of codes for teacher and student behaviors, discourse, and use of materials as well as for lesson topics, classroom organization, and an overall pedagogical practice rating scale. The tool generates data in a spreadsheet format that can be quantified and used to establish patterns of instructional practices. With repeated observations over time, profiles of teaching practices can be constructed.

The validity of the DMT, however, has not been established. Thus, the objective of the present study was to provide support for the validity of the tool by comparing the data it generated to data obtained from video recording a teacher's classroom practices. If evidence is found for its validity, the DMT would be a valuable tool for creating profiles of mathematics instruction. Capturing the same kind of information as video, the DMT would be an attractive alternative to video because of its time- and cost-efficient characteristics. Moreover, it would be a much less intrusive method for gathering data in the classroom, which perhaps would make teachers more amenable to having educational researchers study their pedagogical practices.

Review of the Literature

Reform efforts have aimed to make teaching for understanding central to mathematics education, which constitutes a shift away from the unidirectional transmission of information that characterizes traditional instruction (National Council of Teachers of Mathematics [NCTM], 2000). Current mathematics education reform initiatives in North America have largely been spearheaded by the NCTM's publication of its standards for school mathematics in 1989 and its subsequent revision of the standards in 2000. The updated standards were grounded on the latest research on teaching and learning mathematics (Kilpatrick, Martin, & Schifter, Eds., 2003). One of the main conclusions from this area of research was that students learn what they are provided the opportunity to learn; that is, students will acquire particular kinds of knowledge and skills when they are afforded the conditions that are conducive to them likely being engaged in tasks that address the relevant content (Kilpatrick et al., Eds., 2003).

With traditional instructional approaches in mathematics, most students are quite proficient at executing procedures and performing computations. Their knowledge, however, often lacks depth or conceptual understanding; students appear to be functioning at basic, skills-oriented levels and are unable to modify or transfer their skills to new or more complex situations (Kilpatrick et al., Eds., 2003). To improve this situation, based on research demonstrating that most children are capable of learning more than just basic skills, the NCTM standards specify more ambitious goals for students. To develop deeper conceptual knowledge, the standards are designed with the expectation that students will solve problems, participate more actively in their own mathematics learning, make connections between mathematical ideas, and reason about and explain their mathematical thinking. To facilitate these kinds of activities, teachers need "to adopt broader learning goals, to think differently about mathematics and how students learn it, and to change their instructional methods" (Kilpatrick et al., Eds., 2003, p. 18).

Hiebert et al. (1997) described five dimensions and core features of classrooms that facilitate learning with understanding (i.e., reform-oriented classrooms). First, the kinds of tasks assigned to students are meaningful to them, allow students to use prior knowledge and skills to begin their problem solving, and provide them with the occasion to ponder important mathematical ideas.

Second, the role of teachers is to actively facilitate their students' conceptual understanding. Rather than being the sole authority directing all aspects of the learning process, the teacher selects problem solving tasks with specific goals in mind and shares information when it is necessary for the problem solving process. Moreover, the teacher helps establish a classroom environment in which students work independently as well as collaboratively on tasks, encouraging them to discuss their answers and strategies.

Third, features of the social culture of the classroom facilitate students to view tasks as authentic mathematical problems. For instance, students' ideas are respected and examined, and they are allowed to explore their own strategies for problem solving. The students and the teacher also perceive mistakes as learning opportunities, and they consider the correctness of a solution based on mathematical argument rather than the participants' social status.

Fourth, mathematical tools, which include not only physical materials but also speech, written notations, and any other tools students may use to think about mathematics, are learning supports. Students construct their own meanings for the tools, use the tools to solve problems, and employ the tools to keep records, communicate, and think.

The final dimension is equity and accessibility, in which students at all levels of achievement and from all backgrounds have the right to understand what they do in mathematics. Tasks are accessible, at some level, to all students. Moreover, everyone in the class is heard, and everyone participates.

Mathematics teachers' actual classroom practices, however, appear to not yet conform to these reform initiatives (Stigler & Hiebert, 1999). Some scholars have argued that this discrepancy can explain, at least in part, poor student achievement in mathematics in North American classrooms (NAEP, 2005; Stigler, Gonzales, Kawanaka, Knoll, & Serrano, 1999). In an attempt to discover variables that lead to improved student learning, mathematics education researchers have focused on various characteristics of teachers, including their knowledge of students and of mathematics (e.g., Ball, Hill, & Bass, 2005; Buhagiar, 2008; Fennema & Franke, 1992; Shechtman, Roschelle, Haertel, & Knudsen, 2010), their beliefs about the nature of mathematics and about learning and teaching mathematics (e.g., Cai & Wang, 2010; Marbach-Ad & McGinnis, 2009; Sterenberg, 2008; Thiel, 2010), as well as their practices in the classroom (e.g., Ainley & Luntley, 2007; Brown, Pitvorec, Ditto, & Kelso, 2009; Swan, 2007), which is once again gaining the attention of scholars and the focus of my research.

In this review, I will discuss some of the research on teachers' instructional practices, paying particular attention to the methodology that scholars have used to capture these practices. The focus will be on studies that have used video recordings of teachers' mathematics lessons, which is a common method of collecting data on classroom practices.

Teachers' Pedagogical Practices

Although the qualifications, beliefs, and knowledge of mathematics teachers are important factors to consider, their relationship to student learning is, at present, not clear (Hill, Rowan, & Ball, 2005). Consequently, in current research in mathematics education, there has been a move toward describing the teaching that occurs in the classroom during mathematics lessons. It is an important area of research, as understanding what teachers are actually doing in the classroom will shed light on what and how students learn and their relationship to effective teaching practices.

Researchers have applied a multitude of approaches to examine mathematics teacher practice. For example, time sampling (e.g., Herbel-Eisenmann, Lubienski, & Id-Deen, 2006; Jackson & Neel, 2006; McCaslin et al., 2006), field notes (e.g., Beswick, 2007; Uekawa, Borman, & Lee, 2007), surveys (e.g., Cohen & Hill, 2000; Ross, McDougall, Hogaboam-Gray, & LeSage, 2003), and interviews (e.g., Swain & Swan, 2009) all have been used to study teachers' instructional practices. Currently, however, fine-grained analyses of classroom videotape data are increasingly prominent in the mathematics education research literature (Polly & Hannafin, 2011; Towers, 2010).

Based on my review of the literature of studies investigating mathematics classroom practice using video recordings, the research appears to fall under one of two categories: (a) cross-cultural analyses, and (b) case studies of individual practices. The case studies may be further classified as concerning instruction of specific mathematics topics, establishing mathematics classroom learning communities, and comparing classroom mathematics traditions.

Cross-cultural analyses. The Trends in International Mathematics and Science Study (TIMSS) (Stigler et al., 1999) was a large scale, international study of teaching in seven countries: Australia, the Czech Republic, Hong Kong, Japan, the Netherlands, Switzerland, and the United States. The general goal of the video study was to describe and compare cross-cultural teaching practices. More specific questions that the investigators wanted to address included, "What mathematical content was covered in the lessons?" "How was the mathematics worked on?" and "What was the nature of the classroom discourse?" (Jacobs et al., p. 286). Because of the broad span and nature of these questions, the researchers considered field notes and checklists used to collect observational data to be impractical (Hiebert et al., 2003). Moreover, they believed that video recording would allow them to manage the difficulties involved in obtaining reliable assessments across a large variety of lessons and nations (Stigler & Hiebert, 1999).

At least 100 schools were randomly selected in each nation, and a single lesson each in mathematics and science was videotaped in each school that agreed to participate, yielding more than 1,000 randomly selected lessons recorded. Filming was dispersed consistently over the school year so that the lessons represented the complete range of eighth-grade mathematics and science instruction in each country. A single videographer filmed each classroom by means of two cameras, one that followed the teacher and another that remained stationary to obtain a wide view of the students in the classroom.

For the mathematics portion of the study, a mathematics code development team was convened to establish codes to apply to the video data. The team consisted of bilingual representatives from each of the participating countries and was headed by a mathematics education researcher. Members of the international team were fluently bilingual so they could view the lessons in their native language and not rely heavily on the English transcript.

The mathematics code development team created the TIMSS video coding manual (LessonLab Research Institute, 2005), comprised of 45 codes in seven coding “passes,” which corresponded to separate viewings of the lessons. Each pass focused on a manageable set of related codes.

Most of the codes in the first three passes were coverage codes, which were

> used to code a lesson, or a defined portion of a lesson, in its entirety. All coverage codes have at least 2 mutually exclusive and exhaustive options. Only one of these options can be applied to any defined period of time. (p. 7)

These codes divided a whole lesson into meaningful portions that could be subsequently examined in more detail. In Pass 1, coders noted the start and end times of the lesson, and then partitioned the lesson into durations of public and private interaction. In Passes 2 and 3, coders segmented the lesson into intervals of time when mathematical problems were and were not worked on, when the teacher engaged in managerial tasks, and when the classroom was organized as class work or seat work. Moreover, coders were required to mark the beginning and ending time of each problem, and transcribe the problem statement and problem solution. The fourth pass consisted of occurrence codes for specific events that might take place during the lesson, such as outside interruptions, goal statements, and lesson summaries. Coders noted how many times the particular code occurred within a specific lesson, and at what point the code occurred within a specific lesson.

The fifth and sixth passes addressed questions about each mathematical problem that had been previously identified. For example, coders marked whether the problem was designated as homework, whether it was connected to the real world, how many solutions were presented publicly, and whether the problem was worked on or discussed by the class for more than 45 seconds. Pass 6 included a series of questions about periods of time characterized as private interaction, such as the kind of problems students were assigned to work on, and whether they worked individually or in groups. Another set of codes in Pass 6 examined whether specific resources were used during the lesson, such as computers and calculators. Lastly, in Pass 7, coders partitioned each lesson into sections in line with their objective: discussing previously learned content, introducing new content, or practicing and applying new content.

In addition to the international code development team, several mathematics specialist coding teams with different areas of expertise were employed to construct and apply special codes regarding the mathematical nature of the content, the pedagogy, and the discourse. There were different teams for mathematics problem analysis, mathematics quality analysis, problem implementation analysis, text analysis, and teacher questionnaire coding.

The Learner's Perspective Study (Clarke et al., 2007) also assessed international differences in teacher practice by examining video data of Japanese, German, and American classrooms. The research design was formed to complement the method used in the TIMSS video study by recording sequences of lessons rather than single lessons;

by filming private, interpersonal dialogue, in addition to public speech; and by using video prompts to obtain participants' retrospective descriptions of their antecedent conditions, motives, and intents that prompted observable actions, as well as the consequent construals, significance, and learning outcomes that developed from those actions.

Using the "lesson event" as the unit of comparative analysis, the study analyzed sequences of 10 lessons, which were filmed using three cameras. One camera focused on the teacher, another on a preselected group of students, and the last one on the whole class. During interviews after the lessons, the classroom participants interpreted the events on the videos as they watched the playback. Two coders, working independently, analyzed the video recordings minute by minute, and subsequently compared their results and developed codes based on consensus.

As part of the Mathematics Education Traditions of Europe (METE) project, Andrews and Sayers (2006) compared mathematics teaching in four European nations: England, Flanders, Hungary, and Spain. In particular, they examined differences in the teachers' didactic strategies over a series of four to five lessons in each country on each of four major topics. The researchers chose to film a sequence of lessons to surmount criticism of larger studies (e.g., Stigler et al., 1999) that videotaped only single lessons, resulting in teachers being inclined to present "party piece" lessons.

Videographers focused on teachers, encapsulating all their utterances as well as their work on the blackboard. Generally, a camera mounted on a tripod was placed near the back of the classroom, while teachers wore radio microphones. In addition, a telescopic microphone was tactically positioned to capture as much student speech as feasible. There were some instances in which two cameras were used, one trained on the teacher and the other on the students.

The first two lessons in each series were transcribed and translated into English, making it possible for the researchers' colleagues to code lessons from other nations. Then, over the course of one year, the research team developed a coding scheme. The process involved colleagues from each country in the study observing and discussing one lesson daily in order to develop a descriptive framework for comparing the lessons' episodes, which were defined as the periods during a lesson when the teacher's discernible intention stayed constant. Andrews and Sayers distinguished three categories of episodes that colleagues deemed would allow for meaningful comparison of lessons. They described their use of teachers' ten didactic strategies to code the episodes in the recorded lessons.

Case studies of individual teacher practices. A significant objective of mathematics reform is for teachers to foster classroom learning environments that support doing and talking about mathematics (Fennema & Romberg, 1999; NCTM, 2000). Establishing and sustaining these environments, however, is a complex undertaking for teachers. Studies using video recordings to examine individual teachers' instructional practices have investigated teachers' effectiveness in addressing particular mathematical topics, their attempts to foster effective learning environments, and comparisons of mathematical traditions. The following sections describe these three areas of focus.

Instruction of specific mathematical topics. Stein, Baxter, and Leinhardt (1990) described the association between a fifth-grade teacher's knowledge of mathematics and his teaching practice. They conducted a subject matter interview and card sort task with the teacher, which they then transcribed and summarized. Then, video data of a series of 25 lessons on functions and graphing were transcribed, depicting verbal interactions as well as student and teacher behaviors, and the transcripts were analyzed over three phases. Initially, the lessons were separated into lesson structures. Secondly, the researchers performed a content analysis on segments they categorized as "shared presentations," which were parts of the lesson in which the teacher presented new material. Finally, they singled out particular instructional events that implied connections to the teacher's subject matter knowledge, and explored in depth the nature of these connections in order to determine the manner in which subject matter knowledge may have impacted the teacher's instruction. Stein et al. suggested that the teacher's limited subject matter knowledge led to the reduction in instruction in multiple ways: (a) by being deficient in providing the underpinnings for future learning in the area of functions and graphing; (b) by overstating a limited truth; and (c) by missing occasions to promote meaningful relations between major concepts and representations.

In Martin, McCrone, Bower, and Dindyal's (2005) investigation of variables that may be connected to the understanding of proof, the researchers categorized and deciphered the actions of teachers and students, as well as social factors that were apparent in an honors-level geometry classroom. Martin et al. observed the classroom and took field notes, as well as video recorded the teacher nearly every day for the 4-month period during which proof was a key topic. They transcribed the videotapes, and along with the notes and student-work artifacts, they analyzed the data using a three-part analysis, which included data reduction, data displays, and conclusion drawing. In essence, the process involved simplifying and converting the data, arranging it into a condensed form, and distinguishing apparent patterns or emergent trends in the data. Part of this process involved annotating and coding the classroom transcripts, with codes surfacing from patterns in the data. As codes were refined and grouped, the researchers generated the code categories of the teacher's actions, students' actions, social phenomena, and mathematical phenomena. Then, through an analysis of patterns of when and how codes transpired in the data, the researchers drew conclusions about how teacher actions were related to student actions as well as possibly to students' development of an understanding of proof.

Escudero and Sánchez (2007) examined the subject matter knowledge and pedagogical content knowledge of two high school teachers as they made decisions about introducing particular mathematical topics. The researchers then studied the transformations that occurred in the classrooms as the teachers implemented their instructional plans. The teachers were interviewed prior to the lessons to discuss their lesson plans. Then, both researchers attended each lesson, with one taking field notes while the other filmed from the back of the class. They video recorded each of the teachers as they taught an entire unit of their own design on Thales' theorem (eight lessons and nine lessons, respectively), and transcribed the audio portion of the videotapes. The camera was focused on the teacher's activities as well as particular students who showed their work on the blackboard during whole-class discussions. During small group work, the teachers were recorded as they interacted with the various groups of students.

The teachers' agendas were assessed based on the interview data. Then, Escudero and Sánchez used the video data and field notes to classify teaching practices. First, they distinguished the lesson segments (e.g., presentation segments, supervised practice, and homework verification), considered to be sections of a lesson that have a goal and that serve to distinguish the parts of the whole instructional unit. Then, for each lesson segment, the researchers categorized the teachers' actions that were exhibited to attain various objectives. In the presentation segments, for instance, a possible action was providing "an example/problem for reaching a definition, a property, a theorem, with the constant intervention of the teacher and pupils" (p. 318). The complete set of actions provided the researchers with the structure of the segments. Combining all the data sources, the researchers inferred the motives related to each particular structure. Then they identified the fundamental domains of knowledge characteristics in order to compare the structures associated with each teacher.

Escudero and Sánchez delved further into the teachers' actions, concentrating on the specifics of the mathematical content of each teacher's instructional practices, and in doing so, they found important differences between the mathematical content of the teachers' actions. The first teacher's approach to teaching emphasized active learning, making connections, and took into account students' ideas, difficulties, and prior knowledge. He provided students with situations that would facilitate the discovery of mathematical meanings and he actualized a view of school mathematics in which ideas were interconnected, highlighting the understanding of concepts, especially in relation to procedures. In contrast, the second teacher's approach to teaching involved imparting to students particular information about mathematical concepts, emphasizing algorithms and the use of sequential steps as a means of promoting students' learning. Moreover, Escudero and Sánchez identified particular classroom events that impacted each teacher's instructional practices. The first teacher was responsive to his students' difficulties with specific aspects of the content, which influenced him to depreciate the value of communicating and sharing ideas in favor of the importance of making explicit the mathematical content he deemed mandatory to teach the theorem. On the other hand, the second teacher diminished the significance of difficulties with content, because for him, students' difficulties were not relevant for the introduction of the theorem.

Establishing mathematics classroom learning communities. Sherin (2002) explored the pedagogical challenges experienced by one middle-school teacher as he attempted to establish and sustain a mathematics discourse community in his classroom. The study describes his struggles to balance making students' ideas the basis of class discussions while ensuring that discussions were also mathematically meaningful and productive. Sherin observed and videotaped 78 lessons over the course of an academic year. To capture a large amount of the discourse that occurred, the teacher wore a wireless lapel microphone, and two other microphones were situated around the classroom on students' desks. The sound was then fed through an audio mixer to the video camera. In addition, the researcher collected field notes for all the lessons, and she interviewed the teacher four times during the year.

Sherin analyzed the interview and video data qualitatively, focusing on class discussions. She identified 68 lessons in which class discussion was one of the main pursuits, and coded them on a rough scale of high versus low for the teacher's degree of focus on the process and content of the classroom communication. For more in depth analyses, Sherin examined a subset of 20 lessons, which were transcribed, and used a fine grained analysis of the video to investigate the teacher's role in the discussions.

Specifically, based on previous research on the role of discourse in the mathematics classroom, she examined particular domains of discussion, including the questions posed by the teacher, the teacher's answers to students' questions, and student-initiated and teacher-initiated mathematical content during discussions.

A rigorous year-long study by Hufferd-Ackles, Fuson, and Sherin (2004) aimed to explore the process of four elementary teachers fostering a math-talk learning community in their classrooms as they implemented a research-based mathematics curriculum called *Children's Math Worlds*. The investigators observed the teachers during the school year, although each teacher had different observation schedules that ranged from twice weekly to every other week, at various points in the year. Most observations were videotaped, and those that were not were audio recorded. Two researchers conducted the majority of the classroom observations, with one recording the lesson while the other took detailed notes. Filming focused on following the teacher or other speaker and recording all student work on the board. When lessons were not videotaped, one researcher was present in the classroom taking notes and audio taping the lesson. Both the video and audio data served as permanent records for subsequent analysis.

There were three phases to the data analysis. The first phase took place during the data collection time and informed the data collection process. Through discussions of the detailed observation notes, the researchers set out to identify important changes that were occurring across and within classrooms. Based on the first phase of analysis, one teacher was identified as having exhibited remarkable change over the course of the school year, as her class transformed from being very traditional to becoming a fully realized discourse community. Consequently, her classroom was chosen as the focus of a case study, which occurred in the second phase of analysis.

In the second phase, the researchers analyzed classroom discussions, teacher interviews, and teacher meetings that were transcribed from the video and audiotapes. They established a coding system that classified the data with regards to various themes associated with mathematics reform. The lesson was considered to be the unit of analysis, and within the lessons, instances of classroom discourse that had a clear beginning and ending were labeled as episodes. Hufferd-Ackles et al. found that three themes and the relationships among them soon became apparent as crucial and became the focus of data analysis: evidence of mathematics community, teacher actions, and student actions. They discovered that the growth of the mathematics community was connected to particular teacher actions and/or student actions. Moreover, within these actions, the researchers distinguished four separate but related components that, over time, encapsulated the development of the mathematics discourse learning community. These were: (a) questioning, (b) explaining mathematical thinking, (c) source of mathematical ideas, and (d) responsibility for learning. Within each component, the investigators derived from the data developmental trajectories in the actions of the teacher and students, consisting of four levels (Level 0 to Level 3). That is, they traced changes in actions that transpired over time and built one after another.

Hufferd-Ackles et al. found that the case-study classroom's initial transitions in the math-talk learning framework stemmed in part from the use of the *Children's Math Worlds* curriculum, which encouraged student thinking and explaining of ideas. Additionally, particular practices of the teacher supported her class' transitions from level to level across all the components of the mathematics discourse community and were followed by corresponding changes in student actions. For instance, to transition from Level 0 to 1, the teacher began to emphasize the mathematical thinking behind students' answers rather than on the answers themselves. To move from Level 1 to 2, the teacher started to take on a less central role in the discourse community while she facilitated her students to take on a more principal role. That is, she encouraged student thinking by posing open-ended questions and eliciting detailed descriptions of students' strategies. Moving from Level 2 to 3 involved the teacher's increasing expectations that students would take leading roles in the math-talk learning community as she gave her students the physical and discourse space to do so. She mentored her students to become primary participants in the discourse community and expected them to take increasing responsibility for learning and for evaluating themselves and others. Nevertheless, she actively monitored interactions and remained accessible from the periphery of the classroom to intervene when students needed clarification or when an interaction required her assistance.

The third and final phase of analysis was added to address the issue of generalizability raised by the case study methodology. Thus, Hufferd-Ackles et al. considered the results of the case study within the context of data gathered in the other three classrooms. To inspect the robustness of the findings further, supplementary observations were also performed the following school year.

Black (2004) studied effective teacher-student talk in whole-class discussions using 24 video and audio recordings of one teacher's elementary mathematics classroom collected over the course of five months of participant observation. The video data were collected using a camera with a wide-angle lens and a radio microphone fastened to randomly selected students. She contended that in order to truly comprehend the effect of teacher-student exchanges on children's learning, one must acknowledge the institutional values, social relations, and the unequal distribution of power that pervade the context of the classroom. Such an understanding can only be attained if teacher-student dialogue is observed and analyzed within a framework that recognizes each teacher-student interaction as an implicit mechanism that influences future events, directs and reproduces students' social positioning within the classroom, and contributes to the development of their long-term identities as "learners." Black concluded that "such an analysis reveals underlying processes of unequal pupil participation within classroom interactions which will need to be challenged if 'interactive whole class teaching' is to promote effective learning for all" (p.348).

Black coded the discourse within a multi-layered framework with the objective of interpreting the data using different kinds of contextual knowledge. As a result, the data were split up into separate teacher-student interactions and coded at each of the three different stages in the analysis process: (a) content analysis stage, (b) practice/institutional stage, and (c) cumulative stage. In the content analysis stage, coding pertained to characteristics of teacher-student interactions that were either: (a) productive, meaning that the teacher and student used the interactions to develop and sustain the shared understandings in which the process of learning is rooted; and (b) nonproductive, meaning that the interactions impeded the teacher and student from arriving at a shared understanding of events and, consequently, obstructed the process of learning.

The second level of analysis, or the practice/institutional stage, involved appraising the prominent issues that seemed to impact the meaning of what was being articulated (i.e., points that were not already captured by the previous coding). In Black's investigation, themes that emerged included teacher expectations, and the effect of external social practices, such as time pressure.

In the final level of analysis, or the cumulative analysis stage, a sequence of cumulative procedures was taken to quantify the qualitative analysis so that Black could trace the continuity of students' classroom experiences. The goals of this final stage were to (a) substantiate the earlier interpretations of the data by depicting each teacher-student interaction as one of many cases that had transpired across time, and (b) to integrate another dimension of context into the analysis process that involved the social structure of the classroom and the students' identities within it. Black concluded that teacher-student interactions play an influential part in establishing the social positioning of students within the classroom and this has a significant impact on students' access to the learning process.

Comparing classroom mathematics traditions. Stipek et al. (1998) compared the instructional practices of three groups of teachers (24 teachers in all) on students' motivation. Two of the three groups had communicated a commitment to carrying out reform-oriented mathematics instruction as described in the NCTM's standards. These teachers had participated in workshops and had experience teaching a new unit, Seeing Fractions, which Stipek et al. had developed in accordance with the California Mathematics Framework, and they agreed to teach the unit again during the year of the study. Moreover, teachers in one of these two groups were involved in a comprehensive, year-long intervention arranged to support them in their endeavors to implement instructional reforms. The third group in the study consisted of teachers who used textbooks exclusively, abided by traditional teaching practices, and expressed no interest in reform-oriented mathematics instruction. The teachers in all three groups were videotaped during two or more lessons of the fractions unit.

Stipek et al. developed reliable codes for nine dimensions that characterized teachers' practices: (a) emphasis on student effort; (b) emphasis on student learning; (c) emphasis on student performance; (d) encouragement of students' autonomous work; (e) positive teacher affect; (f) teacher enthusiasm; (g) risk-supportive environment; (h) use of social comparisons; and (i) emphasis on speed. The teachers were rated on each dimension based on a rating scale from 1 ("not at all like this teacher") to 5 ("very much like this teacher"). Raters viewed the videotapes as many times as they considered necessary to make reliable ratings. Each lesson was given two sets of ratings, one that reflected all of the time the teacher directed whole-class lessons and one for the periods in which they supervised student work. The codes along the nine dimensions were factor analyzed to reveal three factors: Learning Orientation (i.e., conveying to students that effort and persistence would pay off), Positive Affect (i.e., being sensitive and kind, showing interest in what their students had to say, and making an effort to make mathematics problems interesting), and Differential Student Treatment (i.e., making students' different levels of performance and understanding very conspicuous). The results revealed that Learning Orientation and Positive Affect positively predicted students' help-seeking, mastery orientation, positive emotions, and enjoyment of mathematics, while the Differential Student Treatment did not significantly predict any of the student motivation variables. Moreover, Positive Affect was the most powerful predictor of student motivation.

In summary, video recordings of mathematics classrooms have been used in a variety of ways to study teachers' instructional practices. The use of video data differs according to the scope of the projects, the goals of the research, and the specific methodologies employed. Regarding scope, the studies in which video data were collected range in size from large-scale international comparative studies (Andrews & Sayers, 2006; Clarke et al., 2007; Stigler et al., 1999) to case studies of individual teacher practices (Black, 2004; Sherin, 2002). With respect to goals, studies have examined different aspects of teacher practice, such as the effectiveness of teachers' instruction of particular topics in mathematics (Martin et al., 2005; Stein et al., 1990), teachers' attempts to foster classroom learning communities (Black, 2004; Hufferd-Ackles et al., 2004; Sherin, 2002), as well as the impact of different classroom traditions on student learning (Stipek et al., 1998). Finally, with respect to methodology, the number of lessons recorded varied widely. Some researchers filmed as few as one lesson per teacher (Stigler et al., 1999), while others recorded more than 50 lessons over a period of several months (Martin et al., 2005) or over an entire academic year (Sherin, 2002). Moreover, the number of cameras used in video studies varied. Some studies used a single camera trained on the teacher (Andrews & Sayers, 2006), whereas others used two cameras, one following the teacher while the other captured the entire classroom (Stigler et al., 1999), and some used three cameras, one focused on the teacher, one on particular students, and one on the whole class (Clarke et al., 2007). Additionally, data coding and analysis of the video recordings greatly differ. Some researchers examine a series of lessons as a whole (Stipek et al., 1998), while others scrutinize the video data in smaller segments, such as a minute-by-minute analysis (Clarke et al., 2007).

Justification and Development of the DMT

Osana et al. (2008) sought to develop an instrument, with at least face validity, that would yield information on the classroom practices of mathematics teachers that was a time- and cost-effective alternative to video recordings. Specifically, the researchers wanted to design a software tool to collect classroom data with the objective to efficiently and objectively construct distinct teaching profiles which, in turn, could be correlated with student learning (see Osana et al., 2008). Modeled after Scanlon and Vellutino's (1997) digitized time sampling tool to observe early literacy teachers, the software program called *Domains of Mathematical Teaching* (DMT) is a digitized time sampling checklist designed to observe mathematics classroom features related to student learning (e.g., Hiebert & Wearne, 1993).

In constructing this instrument, Osana and her colleagues drew upon the research literature on effective teaching behaviors and classroom interaction. For example, Baroody (2003) put forward a classification scheme for describing particular approaches to mathematics teaching. His framework, which consisted of four approaches to mathematics instruction, can account for such instructional practices as teaching style, learning objectives, and student and teacher roles that vary on a spectrum from being primarily procedural to those that are mainly inquiry-oriented. Baroody described teachers who adopt the "Skills" approach as focusing on the mastery of procedural skill by engaging students in repetition and memorization of facts and rules. Intending to teach students, who are perceived to be uninformed, about how to do mathematics, teachers who adopt a skills approach transmit information via direct instruction and practice. Teachers who take on the "Conceptual" approach are similar to those with a Skills approach with the exception that they concentrate on the meanings behind the facts and rules being mastered.

Contrastingly, the “Investigative” approach involves a focus on meaningful understanding of concepts and of skills as well as the development of mathematical inquiry, including problem solving and reasoning. Teachers who take on this approach view mathematics as a process of inquiry as they mediate, guide, and prompt children’s active construction of understanding. Similarly, teachers who adopt the “Problem-Solving” approach also view mathematics as a process of inquiry, and they serve as a “wise partner” in cultivating mathematical reasoning and problem solving in students. That is, the teacher advances the process of inquiry but refrains from setting the agenda or dominating the inquiry. According to Baroody, the Problem-Solving approach is philosophically situated at the opposite end of the spectrum from the Skills approach.

Applying Baroody’s framework, Osana et al. designed the DMT to measure aspects of teaching, such as classroom organization, specific tasks in which the teacher and students are engaged, and the nature of the discourse occurring in the classroom, that can be used to create these types of instructional profiles, including Skills, Conceptual, and Investigative/Problem-Solving, of the teachers observed.

Components and content of the DMT. Osana and her colleagues operationalized several of the components in Baroody’s framework from pilot data (Osana, Lacroix, Pitsolantis, & Rayner, 2007), but other studies and projects also informed the development of the DMT, namely TIMSS (Stigler et al., 1999), Hiebert and Wearne (1992; 1993), and the Study of Instructional Improvement (SII; see Ball & Rowan, 2004). Specifically, the DMT is comprised of eight areas: (a) the mathematics topic, (b) the way in which the classroom was organized, (c) the teacher's verbal content, (d) the students' verbal content, (e) the teacher's behavior, (f) the students' behavior, (g) the materials the teacher used to present tasks to the students, and (h) the materials the students used to solve tasks. Osana et al. (2008) contend that observing these eight domains together objectively characterizes a teacher's instructional practice, providing a framework for describing the teacher's unique instructional profile with respect to teaching mathematics for understanding.

Mathematics topic. The DMT captures the mathematics topic that is targeted in each lesson being observed. Such topics include number concepts, operations, algebra, and geometry (Ball & Rowan, 2004).

Classroom organization. Additionally, the DMT measures the classroom set up within each lesson (Stigler et al., 1999). Specifically, the teacher-student interactions occur within one of two fundamental contexts: class work and seat work organization. Class work organization refers to situations in which the teacher and the whole class are working together. The primary characteristics that are observed during class work organization are: (a) classroom discourse that involves the entire class (i.e., public speech), and (b) a context in which the teacher is working with the majority of the students. During the latter type of classroom organization, for example, a teacher may be introducing the class to a new mathematical concept.

In contrast, seat work organization refers to situations in which the students are working independently of the teacher, either individually or in small groups. The beginning of seat work is usually characterized by the following teacher-student behaviors: (a) the teacher announces that students should begin their work, (b) the students demonstrate a period of silence after the teacher announces necessary information to complete a task, and (c) the students begin working on a task or an activity.

Teacher's verbal content. The teacher's verbal content is coded in one of two ways: (a) discourse that elicits a verbal or nonverbal response from the students, and (b) discourse that does not call for the students to reply to what was articulated (Stigler et al., 1999). Elicited discourse is coded when the teacher seeks mathematical information from the students (e.g., "How many numbers are there between 4 and 7?"). Nonelicited discourse is coded when the verbal content consists of either direct instruction or information about activities that need to be carried out and, in some cases, how to carry out these activities (Stigler et al., 1999). Direct instruction is coded when the teacher's speech content imparts information that is mathematical in nature and does not necessitate a student response.

The other two forms of nonelicited discourse (i.e., information pertaining to activities and how to perform a task) are two types of managerial discourse (Stigler et al., 1999). Managerial discourse is coded when the teacher implores or constrains students' physical behavioral responses (e.g., "Turn to page 47 in your activity book.") and intellectual activities (e.g., "To solve 3 + ☐ = 8, you should use your blocks.").

Student's verbal content. Similar to the teacher's verbal content codes, the student verbal content codes encompass discourse that either is or is not elicited by the teacher (Osana et al., 2008). That is, one of the student elicited response codes is selected when a student verbalizes a response because he or she is elicited to orally communicate (e.g., "There are two numbers in between 4 and 7.").

Incidences in which a student voluntarily vocalizes a mathematical statement (e.g., “I used my fingers to solve that problem.”), a mathematical question (e.g., “Why is the answer 5?”), or speech that does not include any mathematical content (e.g., “I can’t find my book.”) are considered nonelicited responses. All of the student verbal content codes were designed to correspond to the teacher verbal content codes.

Teacher and student behaviors. In addition to teacher-student discourse, the behaviors demonstrated by both students (e.g., speaking, working independently, and getting class work corrected by the teacher) and the teacher (e.g., listening, surveying the classroom, and verifying the accuracy of a student’s performance) are also observed and coded (Ball & Rowan, 2004; Osana et al., 2008). Because it is difficult to attend to multiple behaviors exhibited by all the students during one 10-second interval, coders focus on behaviors displayed by the majority of students or the behaviors of students who are interacting with the teacher. Furthermore, for every teacher behavior there is a corresponding student behavior that may be selected. When a teacher poses a question, for example, the option of selecting the student behavior “answering a question” is available.

Materials teacher used to present a task and students used to solve a task. Finally, the DMT also focuses on the contextual features (such as physical materials) used by both the teacher and the students in the classroom (Ball & Rowan, 2004; Hiebert & Wearne, 1992, 1993; Osana et al., 2008). In particular, coders observe the materials and context the teacher uses to present a task (e.g., mathematical notations, physical materials, and pictures) as well as those the students use to perform the task (e.g., physical materials, tables or charts, and word problems). When the students are working independently or in small groups to perform an assigned task, all the contextual features that were applicable during that time slice are selected.

DMT Program Design and Use

There is a maximum of 17 different DMT decision screens that may appear during coding. Some screens display check boxes so that the coder may select all the options that apply, whereas others feature option buttons and the coder must select only one option from mutually exclusive items. One sample screen is shown in Figure 1 and the entire set is presented in Appendix A.

To use the DMT, a coder needs to be trained beforehand on the operational definitions of the codes in order to quickly recognize behaviors during observation sessions and correctly select codes. Osana et al. (2007) created a detailed glossary on the operational definitions of codes, which is presented in Appendix B.

During a mathematics lesson, the coder observes the teacher-student interactions for periods of 10-second intervals. The DMT features a programmed silent on-screen countdown that appears on the desktop for the final five seconds of the 10-second interval, allowing the observer to reliably and consistently observe the classroom for 10 seconds. Following the 10-second observation, the coder selects codes on a series of decision screens that appear, each with a list of observable behaviors to check off if observed. There is no set time interval for coding a slice, as it depends on the complexity of what is observed during the 10 seconds and the individual coder's speed of going through the screens.

The sequence of the decision screens is directed by the codes that are selected. For example, if the teacher is not presenting a new activity, all of the teacher’s behaviors used to describe how the teacher is presenting the task are not applicable. Consequently, additional decision screens that request codes to be selected to describe the task that was presented (e.g., whether the activity is linked to a previously instructed mathematical topic) do not appear. Another example is that if mathematics is not the instructional topic during the observed time slice, then once the coder has selected Non-Math on the Subject screen, which is the first screen to appear after each observation period, the only screen displayed is the list of nonmathematical topics (Language Arts, Social Sciences, or Art). No additional screen is presented; rather, the coder is prompted to observe for another time interval.

The final screen provides the option of terminating the entire observation session or continuing to observe the classroom for another 10-second time slice. At the end of the observation session, a window for comments appears, providing the coder an opportunity to describe the classroom activities in more detail or convey any out of the ordinary situations that may have occurred during the lesson.

Behaviors that were observed, and therefore selected, during an observation session are sent to a Microsoft Excel spreadsheet that is automatically created whenever a new observation session begins. In this spreadsheet, each row represents one 10-second time slice, and each column represents a DMT code. Whenever a behavior is selected during a given time slice, the presence of the behavior is designated by a 1 and the absence of other behaviors is designated by a 0, as shown in Figure 2.

During coding, if the coder realizes that a code has been omitted or was incorrectly selected as he or she is selecting codes for a time slice, the coder writes down the error on a paper correction sheet as well as the time at which the coding of the slice ends. When the observation session terminates, the coder locates the error on the spreadsheet based on the end time of the slice and makes the correction.

Interrater Reliability of the DMT

The DMT was initially used during a pilot study (Osana et al., 2007) with three objectives in mind: (a) to verify that the behaviors included in the DMT were relevant and that any additional behaviors typically observed in a classroom during a mathematics lesson were not omitted; (b) to refine the operational definitions of the behaviors; and (c) to train a second coder to establish interrater reliability. The second coder was trained over the course of seven observation sessions, in which the average length of the mathematics lesson was 52 minutes and the total observation time was 366 minutes. During the training period, the second coder observed the same 10-second intervals during the lessons as the first coder by the signaling to each other when to start observing, then practiced selecting codes on the DMT independently using a detailed glossary of operational definitions of the codes in the DMT (see Appendix B). When needed, the second coder obtained clarification from the first coder about the appropriate codes to select.

Following the series of training observation sessions, both coders used the DMT in a second mathematics classroom to establish interrater reliability. In particular, the coders observed an additional four lessons in which the average class length was 73 minutes and the total observation time was 293 minutes. During the lessons, the two coders observed the same 10-second intervals and confirmed with each other about the verbal content of the teacher and students during the interval to ensure that they were coding the same information. The last two of the four observations, when the second coder felt most familiar with using the DMT, were selected and used to calculate the kappa coefficient and percentage of agreement. The kappa coefficient was $\kappa = .89$ and the percentage of agreement was 89.67%.

The Present Study

Although the DMT appears on the surface to be a more efficient and effective way to capture a teacher's practice, the validity of the DMT has not been established. Thus, the goal of the present study was to collect data that could lend support to the validity of the DMT. This project is important because of the difficulties and challenges with collecting and analyzing video data. While the attributes of video data may be perceived as advantageous, they may simultaneously be seen as liabilities; to carry out video data collection and analysis, researchers require ample time, labor, and financial resources.

Jacobs, Hollingsworth, and Givvin (2007) described some shortcomings of collecting video data. They asserted that developing a detailed videotaping protocol helps videographers establish what is filmed, but it also restricts the amount of information that is gathered. Hence, researchers must ensure that they collect adequate supporting data in order to understand events on video. Moreover, videographers must be trained extensively to capture the appropriate footage and require continuous feedback on the quality of their work. Researchers must also collect release forms from the participants who are filmed, and if the written agreement is not sufficiently broad, researchers must go back to the participants to gain their consent to use the video in less constrained ways. Participants may also choose to revoke their consent. Finally, Jacobs et al. advise that the video data be considered from multiple perspectives. That is, the data can be coded and analyzed using different theories, and individuals and teams with differing domains of expertise can be sought out to analyze and interpret the data. Assembling a large team of coders, however, necessitates a large budget.

Furthermore, teachers may be deterred from participating in studies that entail video recording because of their anxiety over having invasive cameras permanently record their every move. There are also technological issues to address to ensure that data are properly collected. Researchers must invest in technological equipment to gather and store the data. Once the data are gathered, there is also the long process of analyzing the profusion of data.

Jacobs, Kawanaka, and Stigler (1999) described the task of analyzing video data as a cyclical process of viewing and discussing the video with colleagues, generating hypotheses, creating codes, applying codes, generating quantitative analysis and interpretation, and making connections with the video. This process is usually repeated as a result of additional viewings and discussion when new hypotheses come to light. Such extensive work requires substantial resources. As a consequence, aside from efficiency concerns, this lengthy method is not feasible for researchers who do not have ample budgets and manpower to carry out such complex tasks in a timely manner.

Any study that involves conducting observations faces the issue of observer bias, regardless of whether the observations are made using field notes, paper and pencil checklists, the DMT, or video recordings. Observer bias is a well-known phenomenon that is a threat to the reliability and validity of findings. There are several types of observer bias, including personal bias, which occurs as a result of an observer's beliefs and expectations about an observee. Observer drift is another type of bias, in which the observer becomes less accurate and less precise when recording observations after employing an instrument for a length of time (Boehm & Weinberg, 1997). Inadequate training is also a form of observer error.

In order to have confidence in my observational findings by determining interrater agreement and to address the issue of observer drift, I conducted two DMT observation sessions with another coder who was already thoroughly trained to use the DMT; one session took place before the series of five lessons that were observed with the DMT and video recordings and one occurred after the five lessons. This ensured that I maintained reliable criteria in my use of the DMT.

To further reduce the threats to reliability in this study, I established the rate of agreement between my coding of the video data and the coding of a trained assistant. To this end, I carefully trained a second rater on the video coding scheme and determined the interrater reliability of the coding with the second rater by having her independently code randomly selected segments of the video recordings. By having second coders for both the DMT data collection and the video coding, I was employing investigator triangulation, which occurs when several investigators collect and analyze the data, thereby increasing the internal validity of the study (Merriam, 2009).

The specific objective of this study was to examine one teacher’s practice in her mathematics classroom using two methods of observation: the DMT and video recordings. To do so, data from the DMT and data from the video recordings were compared in four DMT categories: Teacher Elicitations, Direct Instruction, Context of Teacher’s Task Presentation, and Classroom Organization. Further, I created two teaching profiles based on Baroody’s (2003) framework: procedural and reform.

Teachers adopt a variety of instructional styles depending on context, familiarity with the mathematical content, and other factors, but this study focused on the two extremes of Baroody's framework, because distinguishing between all four of the profiles along Baroody's continuum of approaches (Skills, Conceptual, Investigative, and Problem-Solving) would have been problematic to operationalize. By using the approaches at each end of the continuum, I was able to more clearly distinguish the profiles. Using both methods of data collection, I measured to what extent the teacher's profile adhered to a procedural approach or a reform approach. If the DMT captured similar instructional behaviors of teachers in the classroom, then it would be a cost-effective way around the labor-intensive process of video data collection and analysis.

The research questions that were investigated in the present study were the following: (a) In each of the four targeted DMT categories, do the frequencies in each of the variables for the DMT data and the video data co-occur? That is, is there a positive correlation between the number of occurrences observed using the DMT and those observed using the video data? If there is no significant correlation, where are the discrepancies between the DMT and video data? and (b) Does the DMT generate a similar profile of instructional practice as video recordings in each of the target teacher practice measures? That is, for each of the measures, if the DMT data generate a Reform profile, will the video data also generate a Reform profile? Conversely, if the DMT data generate a Procedural profile, will the video data also generate a Procedural profile? A sub-question to the second research question was: If the DMT data and video data do not generate similar instructional profiles, on which measures do the discrepancies lie?

Method

Participant

I used a convenience sampling technique to invite an elementary teacher to participate in the study by being observed teaching mathematics lessons to her students. Miss Shirley (a pseudonym) was a Caucasian, 39-year-old, third-grade teacher at a private English-language school in the greater Montreal area. She had only taught at this school since becoming a teacher and had taught the third grade for six years.

Design

This was a descriptive study designed to compare two ways of measuring the instructional practices of one teacher giving a series of mathematics lessons to her students. I used two different observation methods simultaneously during each lesson: the DMT and video recordings. Five entire mathematics lessons were observed using these two methods. To facilitate the interpretation of the observations, these lessons were drawn from a unit on one topic in mathematics, namely multiplication and division.

Two additional lessons were observed, by myself and another coder, using the DMT only. One of these observation sessions took place just prior to the series of five lessons and the other occurred after the five lessons. The purpose of these two DMT-only sessions was to establish interrater reliability and to address concerns about observational bias.

Instruments and Measures

For the purposes of this study, I constructed two theoretical instructional profiles based on Baroody’s (2003) framework of approaches to mathematics teaching. These two profiles are the “procedural” approach, characterized by a focus on basic skill development, and the “reform” approach, which is characterized by an emphasis on mathematical inquiry and combines Baroody’s conceptions of the Investigative and Problem-Solving approaches. The reason that I considered only two dimensions is that distinguishing between all four of Baroody’s dimensions (Skills, Conceptual, Investigative, and Problem-Solving) would have been, from an observational perspective, difficult to operationalize. For example, distinguishing between the Skills dimension (i.e., procedural) and the Conceptual dimension is, by itself, a thorny problem. Procedural and conceptual knowledge in mathematics may be placed at opposite ends of a continuum, but they are actually quite related and influence the development of each other (Rittle-Johnson, Siegler, & Alibali, 2001). Hiebert and Wearne (1996) asserted that the interaction of conceptual understanding and procedural skill in mathematics is not well understood and makes studying the two notions separately a complex undertaking. In fact, they argue that

> distinguishing between understanding and skill, in any domain, is often difficult and can be controversial. It is difficult to set appropriate boundaries on understanding and on skill. It is difficult and, perhaps, foolish to say that one task measures only understanding and another only skill. (p. 254)

Thus, it is unclear how understanding and skill interact and develop together during instruction and as such, more research in this area is needed before one can justify how to operationalize their occurrence in the classroom. Consequently, differentiating between a procedural and conceptual teaching approach was beyond the scope of the present study. Instead, I focused on the procedural and reform approaches, which were more clearly distinct from each other.

Again using Baroody's descriptions of mathematics teaching, I distinguished these two instructional profiles by considering three specific aspects of a teacher's practice: (a) the focus of instruction; (b) the teaching methods; and (c) the classroom organization. The two observational methods, DMT and video, were compared along these three dimensions of teaching practice. The data were then compiled to construct two instructional profiles for the teacher, one for each observational method, which were then also compared.

Thus, the three aspects of teaching practice (Focus, Methods, and Classroom Organization) served as the measures in this study. To operationalize these measures, I made correspondences between descriptions from Baroody's framework and specific components of the DMT as organized by the tool's teaching practice component. Specifically, for the Focus measure (Figure 3), the variables from the Teacher Discourse (Elicitation) domain from the DMT were used. The Teacher Discourse (Elicitation) category consisted of a number of variables: yes/no, name/state information, name/state procedure, name/state principle, describe/explain/justify, compare, generate a problem, and evaluate.

The Methods measure (Figure 4) involved two categories from the DMT: Direct Instruction and Context of Teacher's Task Presentation. These domains were also made up of a number of variables. Some of the variables for the Direct Instruction category were: describe/explain/justify, compare strategies, and expert modeling. Some of the variables for the Context of Teacher's Task Presentation category were: notations, physical materials, and story/word Problems (see Figure 4 for all variables for the

Methods measure).

Finally, the Classroom Organization measure (Figure 5) was operationalized using the DMT's Classroom Organization category. Again, variables for this measure were: class work teacher, class work students and teacher, class work/seat work combination, seat work individual, seat work small groups, seat work both, teacher interaction, and teacher no interaction.

In order to create distinct profiles of procedural and reform teaching, I applied the teaching practice descriptions from Baroody's framework and identified the level of frequency for the targeted DMT variables to represent a procedural or reform profile, as shown in Table 1. For example, a teacher who adopted a procedural approach would emphasize the rote memorization of basic skills. Consequently, such a teacher would frequently elicit yes/no and name/state (information, procedure, principle) responses from students, but would relatively seldom elicit the other variables in the Teacher Elicitation category (e.g., describe/explain/justify) from the students. In contrast, a reform-oriented teacher would encourage students to develop their mathematical thinking and promote the ability to conduct mathematical inquiry, and as such, would frequently elicit describe/explain/justify, compare, generate a problem, and evaluate responses, while engaging in yes/no and the name/state elicitations less regularly.

Insert Table 1 about here

I excluded the "words" variable from the Context of Teacher's Task Presentation category in Table 1, as both a procedural- and reform-oriented teacher would require the use of words to communicate when presenting tasks. Moreover, “redirection” and “other” from the Teacher Elicitations category were excluded, the former because it concerned modifying student behavior rather than mathematical content, and the latter because the content of the code could be either procedural or reform-oriented.

A percentage frequency score was calculated for the individual variables in the four teacher practice categories, once using the DMT data and once using the video data. Specifically, the number of occurrences of the variables was summed for each observational session. Then, I divided the frequencies of each variable across all five lessons by the total number of slices across all five lessons. This resulted in proportion scores for each variable. The same procedure was used for each of the observational methods (i.e., DMT and video).

To compute an overall score for each measure (Focus, Methods, and Classroom Organization) and therefore construct the instructional profiles, I standardized the frequencies by dividing the total number of occurrences of variables that belong to each measure (by procedural or reform orientation) by the number of “applicable” slices across all five sessions (i.e., slices coded as “not applicable” were removed), producing an overall frequency percentage for each variable that belongs to each of the three measures. This resulted in proportion scores for each measure.

For example, consider the Focus measure. For both the DMT and video datasets, the number of times yes/no and the three name/state variables (information, procedure, and principle) elicitations from the teacher were observed across all five lessons was summed and then divided by the total number of observational slices in which elicitations were applicable. This resulted in a percent frequency for procedural-oriented Focus. Similarly, I computed a percent frequency for the Focus variables that applied to the reform profile (i.e., describe/explain/justify, compare, generate a problem, and evaluate) for both the DMT and video data. The same procedure was used for the Methods and Classroom Organization measures.

To establish interrater reliability with the DMT, a second coder and I observed two lessons with the same teacher and classroom, once before the series of five lessons observed using both the DMT and video recordings began and once afterward. To determine the rate of agreement, I counted the number of times we agreed on the coding of the variables in each of the four DMT categories examined in this study and divided by the total number of instances we agreed and disagreed in our coding of those variables. The percent agreement for the first session was 87.97% and 85.54% for the last session. Therefore, I can reasonably infer that observer drift did not occur and that my coding was reliable.

Coding

DMT. Because of the design of the DMT software, all variables were automatically coded with 1s and 0s during the actual observation sessions by virtue of the observer coding while observing. The software automatically stored the codes in Microsoft Excel spreadsheets. One spreadsheet was created per mathematics lesson (i.e., per observational session). Each row in the spreadsheet represented one 10-second observational slice and contained values (1s and 0s) for each code. All of the DMT codes were represented by the columns in the spreadsheet.

Video. I transferred the video data to a password-protected computer hard drive.

Then, for each lesson, I viewed the video recording in contiguous, 1-minute segments and coded every occurrence of the targeted teacher-related variables included in the DMT (see Figures 3, 4, and 5) using the rubric presented in Appendix C. The rubric for the coding of the video recordings was the same as that for the categories and variables of the DMT in order to make feasible a reliable comparison of the two observational methods.

To make the coding procedure for the video data similar to the coding procedure for the DMT coding, I began by coding 10-second contiguous slices of each video recordings. This resulted in difficulty determining when to code an occurrence of a teacher elicitation when her communication began in one 10-second slice and spilled over into additional slices. To minimize the occurrence of this problem, I decided to code 1-minute slices of the video data. I coded the elicitation in the slice into which the majority of the statement fell.

For Focus and Methods measures, in each 1-minute slice, all occurrences of the variables were coded. For example, if name/state information from the Teacher Elicitation category occurred four times in a single slice, all four instances were coded. For the Classroom Organization measure, however, if more than one classroom organization variable was represented in a single slice (e.g., “class work teacher” that transitioned into “seat work individual”), the type of classroom organization that occurred during the majority of the minute was coded.

The research assistant who conducted the video recordings was trained to code the video data for the purposes of establishing interrater reliability. I trained the assistant by having her learn the operationalized definitions from the video coding rubric and then compared her coding of a random sample of slices from the videos to my coding of the same slices. We met over several occasions to view clips from the recordings and to compare our coding. When we felt comfortable that we were in agreement with our coding, the assistant independently coded a random sample comprising 15% of the video data. I used an online random number generator to randomly select nine contiguous slices from each of the five hour-long recordings for the assistant to code. The percentage of interrater agreement was 81.11%.

Procedure

Using the DMT software on a laptop computer, I observed five of Miss Shirley's mathematics lessons with the same group of students over the course of four consecutive weeks. I scheduled the observation dates with the teacher in advance to accommodate her schedule and to avoid circumstances in which the majority of the session involved test-taking or instruction on nonmathematical subjects.

I conducted the observations sitting on a chair at the back of the classroom and did not interfere in any teacher-student interactions. During the observation sessions, I observed the teacher for periods of 10-second intervals, and then I coded all of the DMT items on the computer screen except for the ones related to student behavior and student discourse, as only the teacher was the focus of the present study.

It should be noted that I had been trained to use the DMT in a number of previous research projects; I was the second coder in the Osana et al. (2007) study. As such, I was very familiar with and accustomed to the use of the DMT as well as the operational definitions of each of the variables as specified in the glossary.

Also at the back of the classroom, using a digital video camera on a tripod, a trained research assistant filmed the lessons at the same time that I observed using the

DMT. Miss Shirley wore a wireless lapel microphone that fed into the video camera's audio input. The assistant's training consisted of one session prior to data collection during which I instructed her on where to focus the camera. That is, the assistant was trained to concentrate on recording the actions and discourse of the teacher, focusing on filming her head and upper body, and she avoided filming the students as much as possible.

During the two observation sessions used to establish DMT interrater reliability, the second coder and I were seated next to each other at the back of the classroom, each equipped with laptop computers. Whoever finished coding a slice first waited for the other person to finish, and then we nodded to each other to signal the beginning of the next observational slice.

It should be noted that the second coder was already acquainted with the use of the DMT; she played a key role in the conception and design of the software, was the first coder in Osana et al.'s (2007) study, and had been involved in a number of other projects employing the DMT.

Results

This section begins with a presentation of descriptive statistics of the data collected, followed by quantitative analyses to address my two research questions.

Descriptive Statistics

A total of 339 10-second slices were observed using the DTM over the five hour-long mathematics lessons, averaging 67.8 slices per lesson. There was a total of 304 contiguous 1-minute slices of video data coded over the five video recordings of the lessons, with a mean of 60.8 slices per videotape (each videotape contained the recording from one lesson). The total frequencies and percent frequencies of the DMT variables that were observed across all five lessons using the DMT and video recordings are presented in Table 2.

Figure 6 illustrates the percentage of total slices for the teacher elicitation variables observed with the DMT and video. The most common type of teacher elicitation, when it was observed to occur, was name/state information for both the DMT (15.04%) and video (76.32%). The most recurrent variable coded in the teacher elicitation category using the DMT, however, was "not applicable" (67.85%). When the teacher was not eliciting during a 10-second DMT slice, she may have been engaging in other behaviors such as listening to her students respond to her elicitations, checking her students' work, or employing managerial speech; these DMT variables were not examined in the present study.

As can be seen from Table 2 and from the graph in Figure 7, according to both the DMT and video data, direct instruction seldom occurred as it was coded as "not applicable" most of the time. As is the case with the teacher elicitations coded as "not applicable," when the teacher was not practicing direct instruction, she may have been executing alternate behaviors such as listening to her students speak, a variable that was not investigated in the present study. When direct instruction did take place, name/state information was the most common type for both the video (18.75%) and the DMT (6.19%).

The DMT and video data were in agreement that words (15.34% for DMT; 15.46% for video) and story problems (13.27% for DMT; 13.16% for video) primarily formed the context of the teacher's task presentation, although task presentation was most often coded as "not applicable," as shown in Table 2 and Figure 8, which displays the percentage of total slices for the context of teacher's task presentation variables ascertained using the DMT data and video data. When the teacher was not presenting tasks, she may have been performing other actions such as engaging in managerial discourse, which was not explored in the present study.

Insert Table 2 about here

As seen also in Table 2 and the total percentage of slices graphed in Figure 9, seat work was the typical form of classroom organization based on both the DMT and video, occurring nearly two-thirds of the time. Seat work, such as seat work individual, seat work small groups, and seat work both (individual and small groups), occurs during a lesson when students work independently on assigned tasks, either alone or in small groups, and the type of talk is mostly private. In Miss Shirley's classroom, the organization was nearly evenly distributed between two types of seat work and one type of class work: seat work individual, seat work small groups, and class work teacher and students. Both forms of data unanimously indicated that during seat work, the teacher nearly always interacted with her students.

Analyses

Research question 1: Correlation between occurrences observed using DMT and video data. To address the first research question, I examined patterns in the frequencies of each variable in the four targeted teaching practice categories (Teacher Elicitations, Direct Instruction, Context of Teacher's Task Presentation, and Classroom Organization) to determine if the frequencies co-occur for the DMT data and video data. That is, I assessed whether there was a positive correlation between the number of occurrences observed using the DMT and those observed using the video data by comparing the frequency percent scores for the variables that belong to each DMT category as generated by the DMT to the frequency percent scores for the same variables as generated by the video analysis.

A scatterplot of the DMT data and video data is presented in Figure 10 for the Teacher Elicitation category. Each data point represents one variable within each DMT category. Two values were assigned to each data point: (a) the percent frequency of the target variable as generated by the DMT and (b) the percent frequency of the target variable as generated by the video data. The frequencies for the DMT data were plotted on the x-axis and those for the video data were plotted on the y-axis.

As can be seen in Figure 10, as the DMT data points increase, the video data points show a corresponding increase, except for one outlier, which represents the "not applicable” variable. Specifically, the DMT data have a higher percentage of Teacher Elicitation slices coded as “not applicable” in comparison with the video data.

I also computed Pearson product-moment correlation coefficients for these data points. For the Teacher Elicitations category, there was no significant correlation between the DMT and video, $r(11) = .298$, $p = .374$. When the outlier “not applicable” variable was removed, however, a strong positive correlation resulted, $r(10) = .989$, $p < .01$.

Figures 11, 12, and 13 show more apparent patterns of corresponding increases between the DMT and video data points. For Direct Instruction, Context of Teacher’s Task Presentation, and Classroom Organization, the DMT and video percent frequencies appear to co-occur. That is, as the DMT data points increase, the video data points show an analogous increase, indicating that the patterns of teacher behavior observed with the DMT correspond with those observed with the video data.

Moreover, the DMT and video were strongly positively correlated for Direct Instruction, $r(7) = .982$, $p < .01$, as well as Context of Task Presentation, $r(9) = 1.000$, $p < .01$, and Classroom Organization, $r(8) = .998$, $p < .01$. Given these results, strong support is provided that the DMT and video generate similar teacher profiles with regard to direct instruction, task presentation context, and classroom organization. The teacher elicitations category, however, may not be comparable between the two data collection methods if the “not applicable” variable is included in the analysis.

Research question 2: Profiles of instructional practice generated by DMT and video data. To address the second research question of whether the DMT generated a similar profile of instructional practice as video recordings in each of the target teacher practice measures, I first determined the frequencies of the variables in each of the four

DMT categories where the category was applicable, as shown in Table 3. That is, I calculated the percent frequencies of each of the variables by summing the number of occurrences across all five lessons and dividing by the number of slices that were applicable to the particular category. For example, for the Direct Instruction category, I subtracted the number of “not applicable” slices from the total number of slices for each of the observational methods to get the number of “applicable” slices. This resulted in percent frequencies for each type of direct instruction when the teacher actually engaged in direct instruction.

For the Classroom Organization variables, because “not applicable” is not an option to be coded for this category (i.e., a type of classroom organization is always coded for each slice), I determined the percent frequencies based on whether it was class work or seat work. For instance, I added the number of occurrences of the three class work variables (CW teacher; CW teachers and students; CW/SW combination) and divided by the total number of occurrences of class work to obtain the percentages of each type of class work.

Then, for each of the measures (Focus, Methods, and Classroom Organization), I assessed whether the DMT data generated a reform profile when the video data generated a reform profile, and conversely, whether the DMT data generated a procedural profile when the video data also generated a procedural profile. Recall that to do this, for each method of observation, I summed the frequencies of the targeted variables that encompassed a procedural orientation, as specified in Table 1, for each of the three measures and divided by the total number of “applicable” slices to obtain the procedural frequency percentages for the DMT and video. Similarly, I summed the variables that comprised a reform orientation, as identified in Table 1, for each measure and divided by the total number of "applicable" slices to obtain the reform frequency percentages for each observation method.

Figure 14 demonstrates that both the DMT and video indicate that Miss Shirley has a procedural profile for her focus of instruction. The DMT data showed that the teacher engaged in a procedural-oriented focus 66.97% of the time that she elicited responses from students, while the video data revealed that 143.35% of the occurrences of elicitations were of the procedural variety. (A percent frequency can be greater than 100% for the video data when the coding of every occurrence of a variable in each 1-minute slice of the video data resulted in the total number of occurrences of a variable exceeding the total number of slices.) As can be seen in Table 3, when the teacher elicited, the majority of her elicitations were name/state information according to both the DMT (46.79%) and video (99.15%). Moreover, the DMT data and the video data agree on the elicitation variables that seldom or did not occur. For instance, the data from both observation methods found that the teacher did not employ "compare" or "generate a problem" elicitations.

Insert Table 3 about here

Examining only the DMT data, Figure 14 shows that, by a factor of 4.06, the teacher is more procedurally-inclined than reform on the Focus measure. Similarly, we may deduce from the video data that the teacher is more procedural- than reform-oriented, by a factor of 4.45. Thus, with both methods of observation, we would arrive at the same conclusion about Miss Shirley's focus of instruction profile.

Figure 15 shows that Miss Shirley’s teaching methods lean toward a reform orientation, as revealed by both the DMT (105.43%) and video data (94.41%). (A percent frequency can exceed 100% when the number of occurrences exceeds the number of applicable slices. The Methods measure, which consisted of two teacher practice categories [Direct Instruction and Context of Teacher’s Task Presentation], was calculated by summing the frequency of variables included in each instructional profile [i.e., procedural and reform] and dividing by the sum of the total number of slices in the two categories subtracted by the number of slices coded as “not applicable” in the two categories.) Both observation methods, however, demonstrate that relative to reform methods, there was still a moderately high frequency of procedural-oriented methods. The reform variables predominate over the procedural variables by a factor of 1.83 for the DMT data and 1.39 for the video data. Thus, for the methods profile, the conclusion would be stronger that Miss Shirley is a reform teacher with the DMT compared to the video data.

As can be seen in Table 3, story problems were the most prominent reform-oriented variable in Miss Shirley's methods profile, as they were used 84.91% of the time that she presented tasks according to the DMT and 86.96% according to the video. Additionally, the data from the two observation methods are in agreement that the teacher did not use tables or games, and she relatively infrequently used pictures (26.42% of the time according to the DMT data and 32.61% of the time according to the video data).

Further, the DMT and video data are unanimous that Miss Shirley adheres to a reform profile in her classroom organization, as shown in Figure 16. Both observational methods agree that the teacher employed reform-type classroom organization (i.e., high frequencies of “seat work small groups” with teacher interaction and “class work teacher and students”) 78% of the time, while her frequency of the procedural-type of classroom organization (i.e., class work teacher and seat work individual with no teacher interaction) was 22%.

It may be concluded, then, that the DMT reveals the same instructional profiles as the video for the three measures (Focus, Methods, and Classroom Organization). For the Methods measure, however, both methods of observation produce a teaching profile that is less distinct.

Discussion

The objective of the present study was to collect data that would lend support to the validity of the DMT software tool for observing teacher practices in the elementary mathematics classroom. In particular, using two methods of observation, the DMT and video recordings, I predicted convergence of the frequencies of the variables in the following four DMT categories: (a) Teacher Elicitations, (b) Direct Instruction, (c) Context of Teacher's Task Presentation, and (d) Classroom Organization. For example, I examined if there was agreement between the two observation methods on the frequency with which the teacher requested that her students engage in discourse that stimulated mathematical inquiry compared to the frequency with which she elicited short "fact" responses, how often she engaged in direct instruction behaviors, and with what frequency she arranged her students into the various types of classroom organization.

To meet these objectives, using the DMT, I observed a teacher carrying out a series of five mathematics lessons while the lessons were simultaneously video recorded. I then compared the frequencies of the variables in the four targeted teacher practice categories generated by the DMT to those generated by the video recordings. Additionally, I used the data from the two observation methods to construct instructional profiles for each of the study's three measures (Focus, Methods, and Classroom Organization).

The overall results of the present study indicated that the DMT data produced similar patterns of frequencies to the video data. In particular, significant positive correlations between the percent frequencies of occurrences observed using the DMT and those observed using the video data were found for three of the four targeted DMT teacher practice categories: Direct Instruction, Context of Teacher's Task Presentation, and Classroom Organization. For instance, both observation methods found that Miss Shirley relatively seldom engaged in direct instruction, but when she did, it was usually in the form of providing facts. To a lesser extent, she also provided explanations and verbally modeled a concept or procedure, such as when she demonstrated to her students how to solve a particular word problem. When she presented tasks, the DMT and video data were in agreement that Miss Shirley frequently employed words and problem solving when she presented tasks but she did not use tables or games. Additionally, the two observation methods were unanimous that she organized her classroom so that students regularly worked together in small groups as well as individually on assigned tasks while the teacher interacted with them and checked their work, and within whole-class situations, she and her students acted as co-leaders in mathematical activities rather than making herself the primary speaker.

There was, however, no significant correlation between the percent frequencies for the DMT and video for the Teacher Elicitations category. Nevertheless, when the outlier "not applicable" variable was removed from the Teacher Elicitations category, a significant positive correlation resulted. For instance, the DMT found that Miss Shirley often questioned her students in ways that elicited short responses such as stating facts and to a lesser degree, she requested more elaborate explanations; the same conclusions could be drawn from the video data. The high frequency of slices coded as "not applicable" by the DMT in the Teacher Elicitations category occurred because the teacher was often engaging in alternative behaviors within an observed 10-second slice, such as listening to her students speak, participating in managerial discourse, checking students' work, giving directives, and so on. It should be noted that the DMT has various categories that code these and other behaviors, but they were not captured by the present study, which only examined four specific categories. The video data did not reflect the same high frequency of slices coded as “not applicable” because I coded every instance of a teacher elicitation in 1-minute contiguous slices of the video. Consequently, there were more instances of the teacher eliciting at some point within each 1-minute slice of the video recordings.

Additionally, I created two theoretical instructional profiles based on Baroody’s (2003) framework of approaches to mathematics teaching: the procedural approach and the reform approach. The present study found that the DMT generated a similar profile of instructional practice as the video recordings in each of the target teacher practice measures (Focus, Methods, and Classroom Organization). Specifically, for the focus of instruction measure, both the DMT data and video data revealed that the teacher had a procedural profile. That is, the type of questions Miss Shirley directed at her students tended to elicit short pieces of information, which may have encouraged rote memorization of facts rather than developed her students’ ability to conduct mathematical inquiry. With respect to the methods and classroom organization measures, however, both observational methods depicted the teacher as adhering to a reform profile. That is, Miss Shirley’s employed methods that revolved around problem solving and student-centered learning. For example, the teacher infrequently engaged in direct instruction and she often employed story problems involving everyday situations that provided opportunities for her students to learn and explore mathematics. Furthermore, Miss Shirley organized her classroom in such a way that she was not directing all aspects of the learning process; rather, her students regularly worked together in small groups and were engaged in semi-independent activities while she actively monitored their progress and at times intervened to offer guidance. Therefore, the current study showed that when using the data from the DMT to assess a teacher's orientation as either procedural or reform, one would arrive at the same conclusion as when using the video data.

For the Methods measure, although both the DMT data and the video data revealed that the teacher was reform-oriented, the DMT data revealed a stronger discrepancy in the frequency percentages between the procedural and reform profiles compared to the video. That is, the DMT data found that Miss Shirley's methods of instruction were more heavily aligned to a reform approach than a procedural approach when compared to the video data. As a consequence, when assessing teaching methods, DMT data may be more inclined to favor a reform profile compared to video data.

Conclusions

The findings from this study provide support that the DMT may be used instead of video recordings to obtain data on teacher practices in the elementary mathematics classroom. In fact, the DMT is a more practical alternative to video as a method of collecting classroom data. With the DMT, sufficient time is required at the front end of a study before data collection begins, as the coder needs to be trained on the operationalized definitions of the variables used in the DMT. Once the coder is trained, however, carrying out the data collection with the DMT requires much less time, labor, and fewer financial resources than video; the only equipment needed is a laptop computer, and the data are coded in real time during an observation session. Moreover, a large number of observational slices can be obtained during an observation session with reasonable confidence that, over a series of sessions, the samples are representative.

The present study showed that despite its “checklist” format, the data from the DMT revealed a rich picture of a teacher’s classroom practices. Frequency percentages of four teacher practices, namely elicitations, direct instruction, context of task presentations, and classroom organization, were extracted from the data. Additional categories in the DMT that were not the focus of the current study may be used to further elucidate a teacher’s practices. The DMT data were also used to create instructional profiles of the teacher. Although this study examined procedural and reform orientations, teaching profiles may be modified depending on the researcher’s goals. For example, the other categories in the DMT that were not the focus of the current study may be added to the profile constructs or used to create entirely different ones.

This study served to present an observational tool that is a precedent in educational mathematics research. Moreover, the study presented evidence that lends support to the validity of the DMT as an observational tool used to examine teachers’ instructional practices. As a result of the present study, the DMT may be shared with other researchers who may use the tool in place of video recordings to collect teacher practice data in a more efficient manner. In fact, interest in the tool has been substantial, and several scholars have asked for a copy of the software for their own research (H. P. Osana, personal communication, August 15, 2011). This study is important because it lends credibility to the data that are generated by the DMT and as such makes it possible to share the tool with others.

The DMT is an efficient and systematic means of obtaining data on classroom practices. If the goal of a study is to examine patterns of frequencies in a teacher’s elicitations, or examine whether a teacher is reform- or procedural-oriented in her classroom practices, as in the present study, the DMT would be an ideal instrument as the DMT data were found to yield percent frequencies that were comparable to those calculated using the video data. The DMT could be suitable for research that compares frequencies and percentages of targeted teacher behaviors, and has already been used by Rayner, Osana, Lacroix, and August (2011), who investigated the role of classroom practice in the relationship between teacher knowledge and students' mathematical development. Specifically, they used DMT data to determine the frequency of teacher interactive behaviors (i.e., posing and answering questions, providing encouragement, and checking student work/observing the classroom) of 14 teachers who were rated as either high or low in subject matter knowledge as well as high or low in pedagogical content knowledge. They found that the first-grade students' mathematical development was related to their teachers' mathematical knowledge for teaching, but it was moderated by the frequency of interactive behaviors. For example, for students' mathematical proficiency on number sentences and problem solving, the results showed that if a teacher had weak pedagogical content knowledge, it can be "buffered" by limiting the amount of interaction they had with students.

Still, for some types of studies, video recordings would be the better method of data collection. The DMT is static in that the variables to be examined are already set into the software program. In contrast, there is flexibility with video data since one can tailor the data to a wider variety of research questions, including those that are more focused. Furthermore, because of the DMT's tendency to capture more "not applicable" coded slices for the Teacher Elicitations category compared to the video data, if the objective of a line of research was to focus primarily on the verbal content of the teacher, such as in a discourse analysis, then video recordings would yield a more accurate picture, because one would be able to code every single occurrence of specific types of elicitation. Additionally, the DMT can provide a summary of quantitative data based on frequencies of observed behaviors, but because the data are coded in real time, the researcher cannot return to the actual moment of a specific occurrence in the classroom to repeatedly review and further analyse it, which one can do with video recordings. The following are two examples of studies in which the DMT would not have been able to provide data sensitive to the research questions that were posed.

Franke et al. (2009) used video and audio recordings of lessons on mathematical equivalence to examine three teachers' instructional practices, specifically focusing on the kinds of questions the teachers asked when supporting students in making their thinking explicit. They selected teachers who had participated in professional development on algebraic reasoning based on Cognitively Guided Instruction (Carpenter, Fennema, & Franke, 1996), which emphasizes students' thinking and communication in the mathematics classroom. Using an iterative process stemming from the literature on mathematical discourse as well as from their inspection and discussion of the data, the researchers developed a coding scheme to classify the questions teachers asked to encourage students to clarify or elaborate their initial explanations into four categories. These were: (a) general questions, which did not correspond to anything specific a student said; (b) specific questions, which related to something in particular in a student's explanation; (c) probing sequences of specific questions, which comprised a sequence of more than two interconnected questions about something specific that a student said and involved multiple teacher questions and student responses; and (d) leading questions, which occurred when the teacher guided students toward particular answers or explanations. The DMT would not have been an appropriate instrument to use in this study because it is incapable of targeting the specific types of questions that were examined. Further, the fixed nature of the DMT program would not have allowed for the iterative analysis process. The DMT is also not designed to capture and follow the sequential structure of discourse exchanges between the teacher and students that Franke et al. investigated.

In another study, Osana et al. (2011) used video recordings to study six teachers as they implemented inquiry lessons on mathematical equivalence. In particular, they examined the teachers' actions to identify instances when the teachers generated "Probes" or "New Equations" during their lessons. Probes were questions the teacher posed in response to students' statements, and were further categorized according to one of four objectives the teachers had for articulating them: (a) to uncover the reasoning behind a student response, (b) to clarify, (c) to verify the interpretation of a student response, or (d) to draw attention to an important mathematical idea. New equations were further classified as either "Challenges" or "Follow-up Problems." Challenges were considered to be equations the teacher presented on the board or verbalized in response to a student's incorrect explanation, while follow-up problems were equations that were presented in response to a student's correct explanation. Again, it would not have been ideal to use the DMT in place of video recordings to investigate the teacher practices in this study, because of the specific nature of the elicitations and tasks that were analyzed.

Limitations and Future Research

The findings from the present study should be interpreted with caution because of the small sample size, since only one teacher was observed in this study over a series of five lessons. Future studies need to be conducted with more teachers and observation sessions to establish whether the results are generalizable across a variety of teachers. Another limitation is that it examined only four DMT categories. As such, the remaining categories need to be validated in future research.

Furthermore, despite the present support for the validity of the DMT, it still represents a single source of data. The current study also validated the DMT data against a particular kind of video analysis technique (i.e., coding contiguous 1-minute slices of the recordings using a rubric based on the DMT's operationalized definitions of codes). Reflective video analysis, in which the teacher views the recordings of her classroom practice and reflects on her specific goals and strategies when presenting specific tasks or engaging in a particular line of questioning, would have been a means to triangulate the data. Highly descriptive studies are more credible if multiple sources of data are used to triangulate (Merriam, 2009). Multiple data sources would provide even richer data and the ability to make stronger conclusions.

Moreover, the current study did not include student performance data to correlate with teacher practices. Ultimately, the greater purpose of assessing to which instructional profile a teacher adheres is to determine its impact on students' mathematical learning. As such, a larger study that includes multiple teachers and student performance data is needed to determine whether different instructional profiles affect student achievement in mathematics. There is a need for valid and appropriate measures of teaching practice, but even the most valid instrument does not matter if the observed practice has no effect on student learning.

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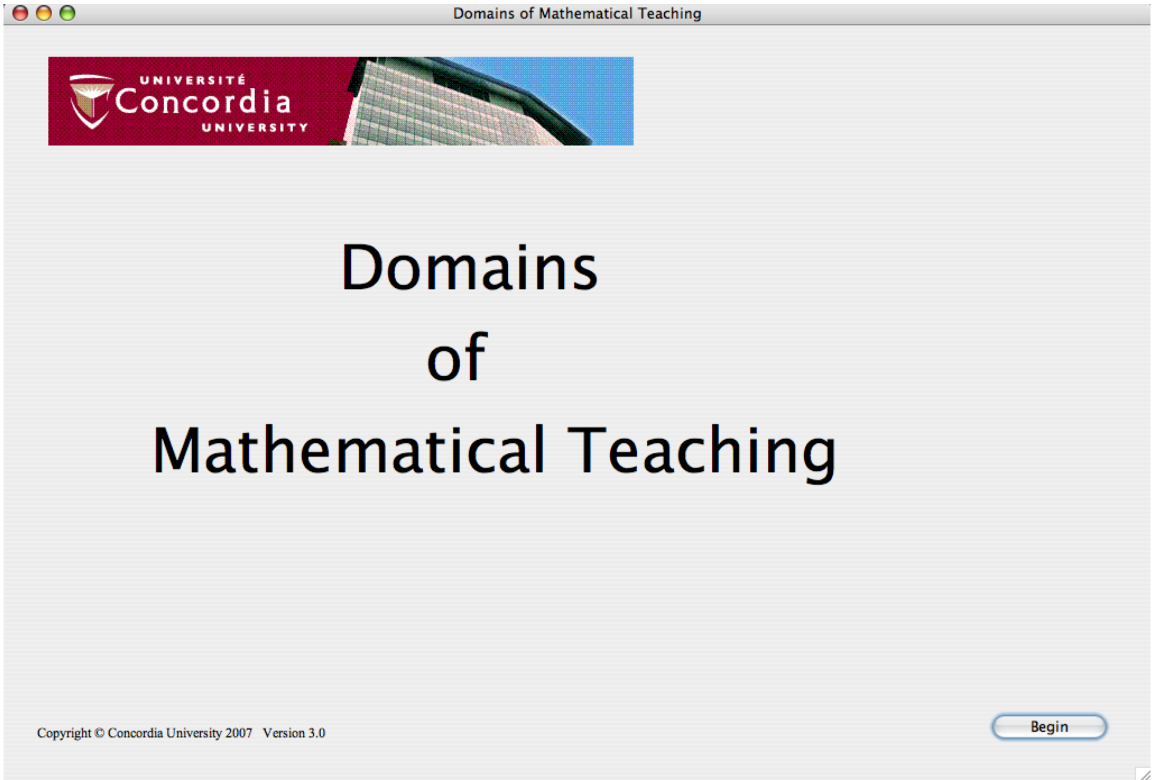
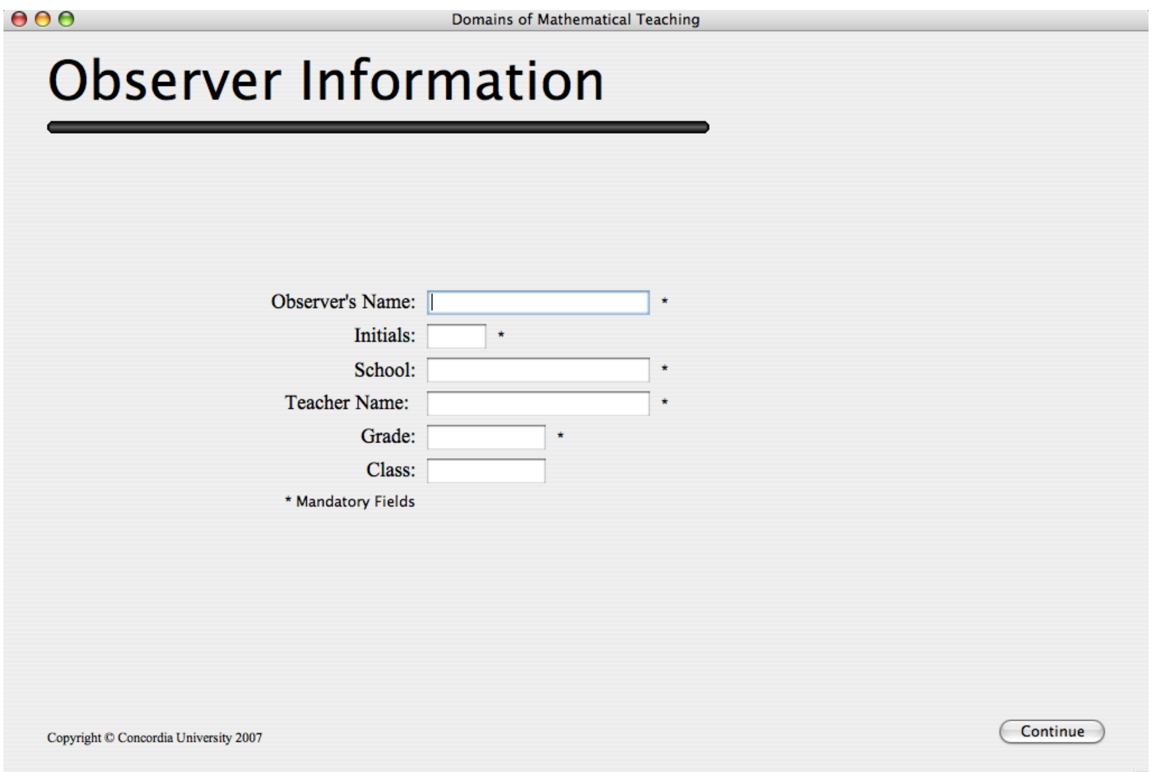
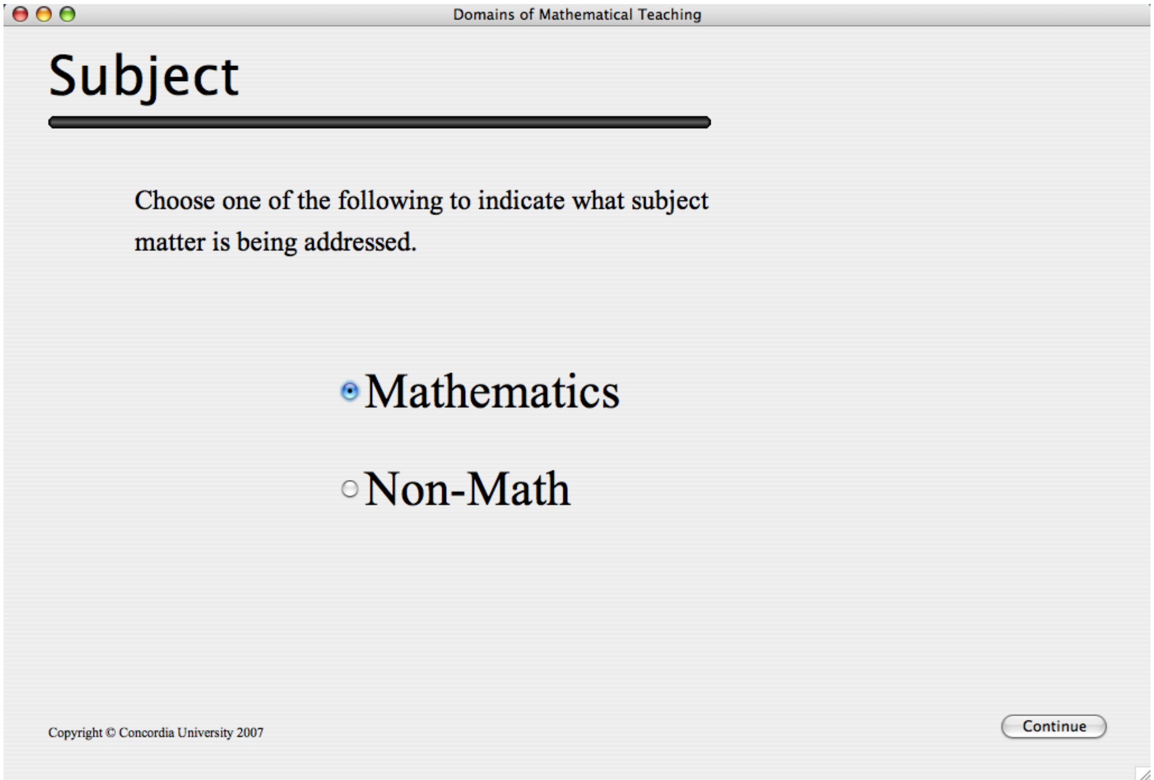
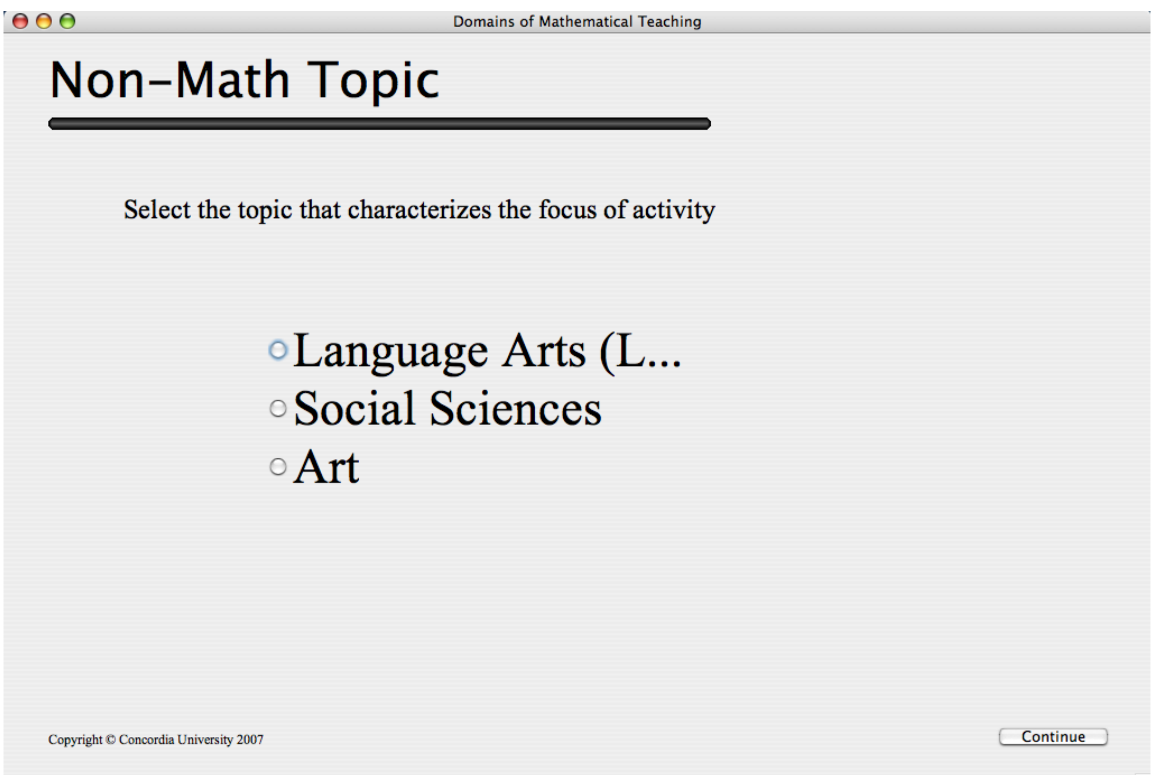
Appendix A

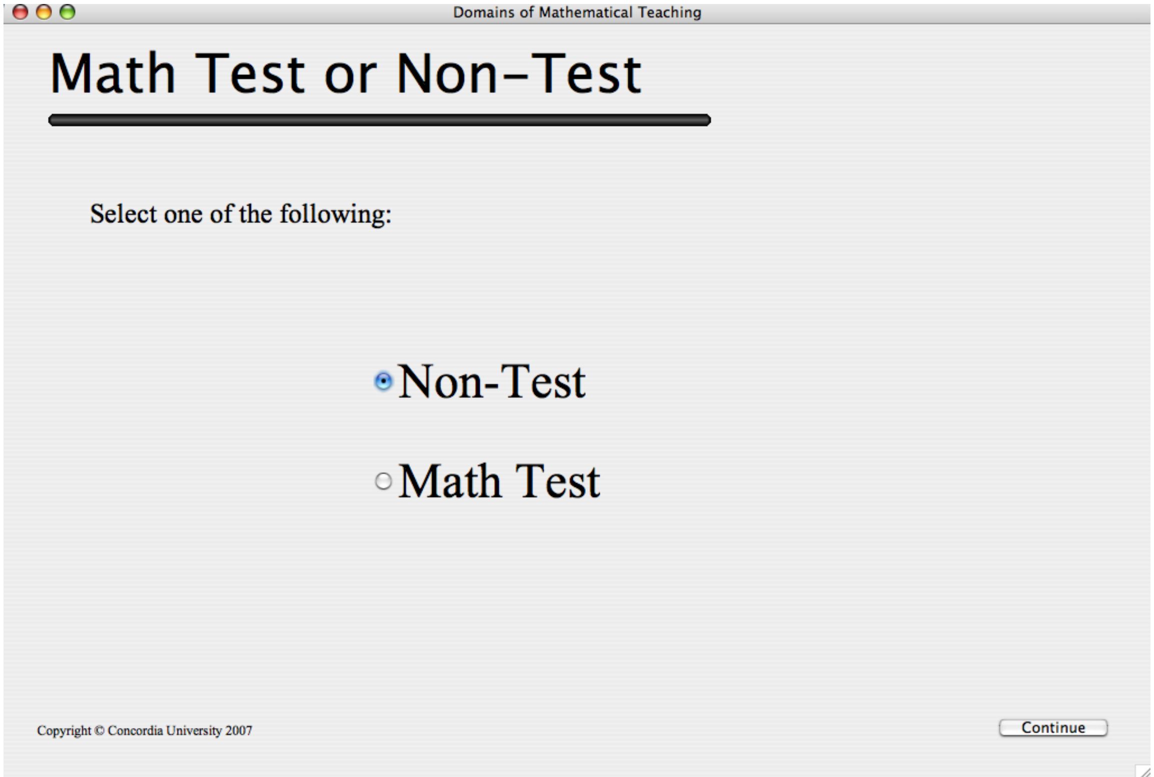
DMT Screens

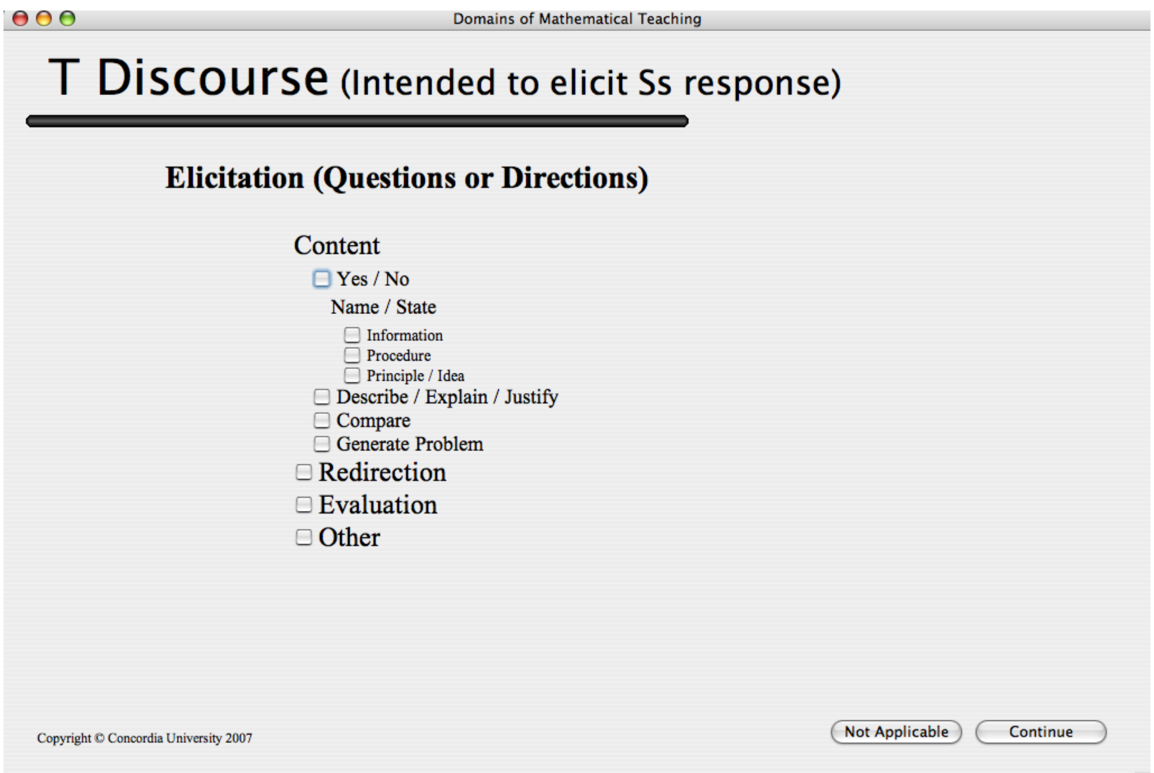

Domains of Mathematical Teaching
UNIVERSITÉ Concordia UNIVERSITY
Domains
of
Mathematical Teaching
Copyright © Concordia University 2007 Version 3.0
Begin

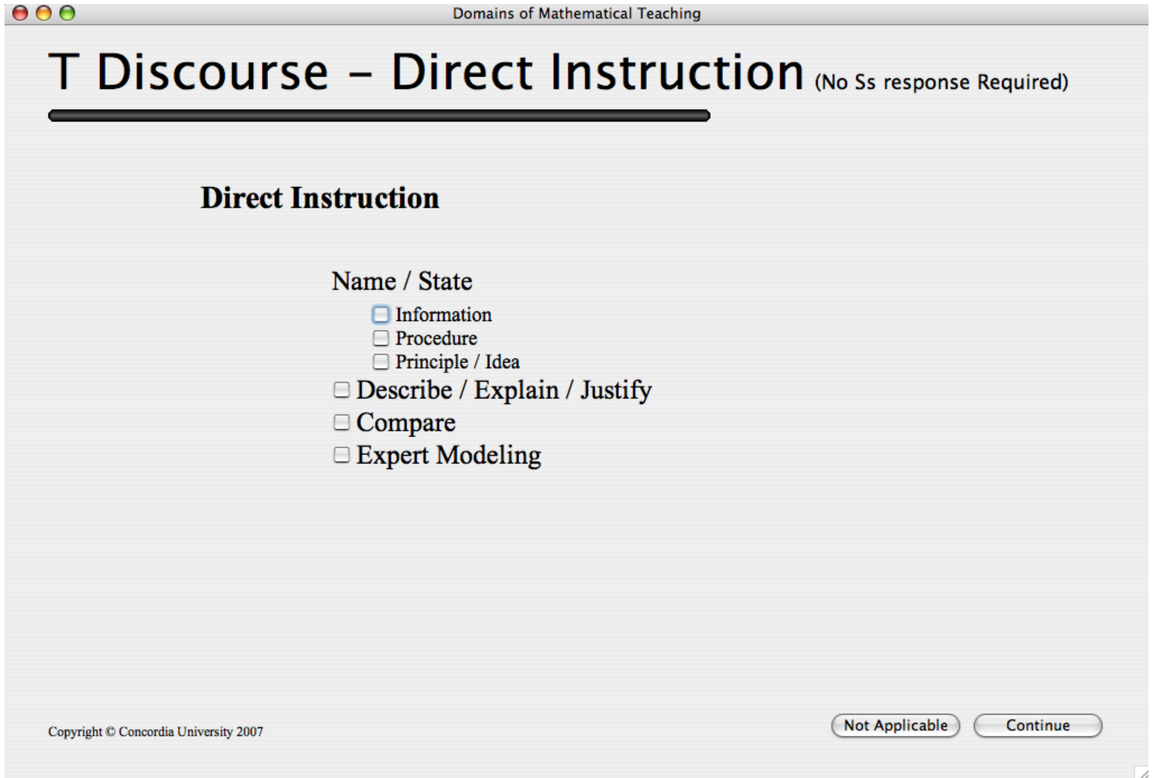

Domains of Mathematical Teaching
Observer Information
Observer's Name: *
Initials: *
School: *
Teacher Name: *
Grade: *
Class:
* Mandatory Fields
Copyright © Concordia University 2007
Continue

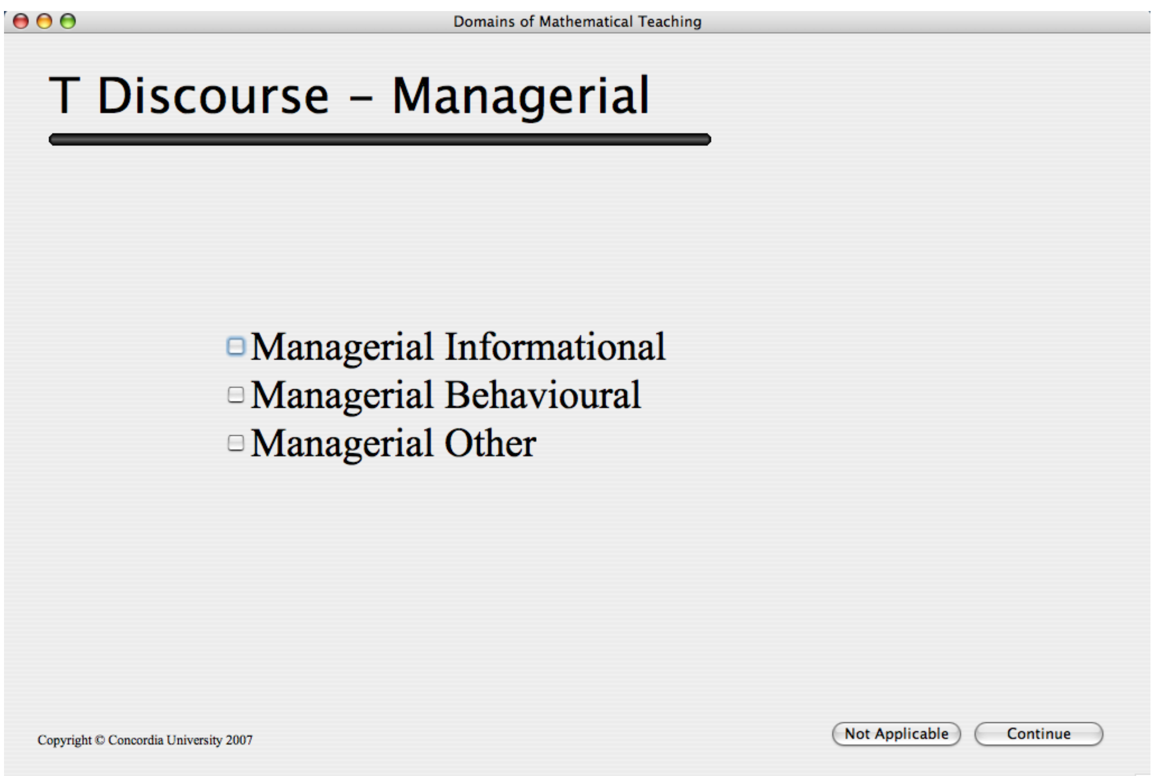

Domains of Mathematical Teaching
Subject
Choose one of the following to indicate what subject matter is being addressed.
Mathematics
Non-Math
Copyright © Concordia University 2007
Continue

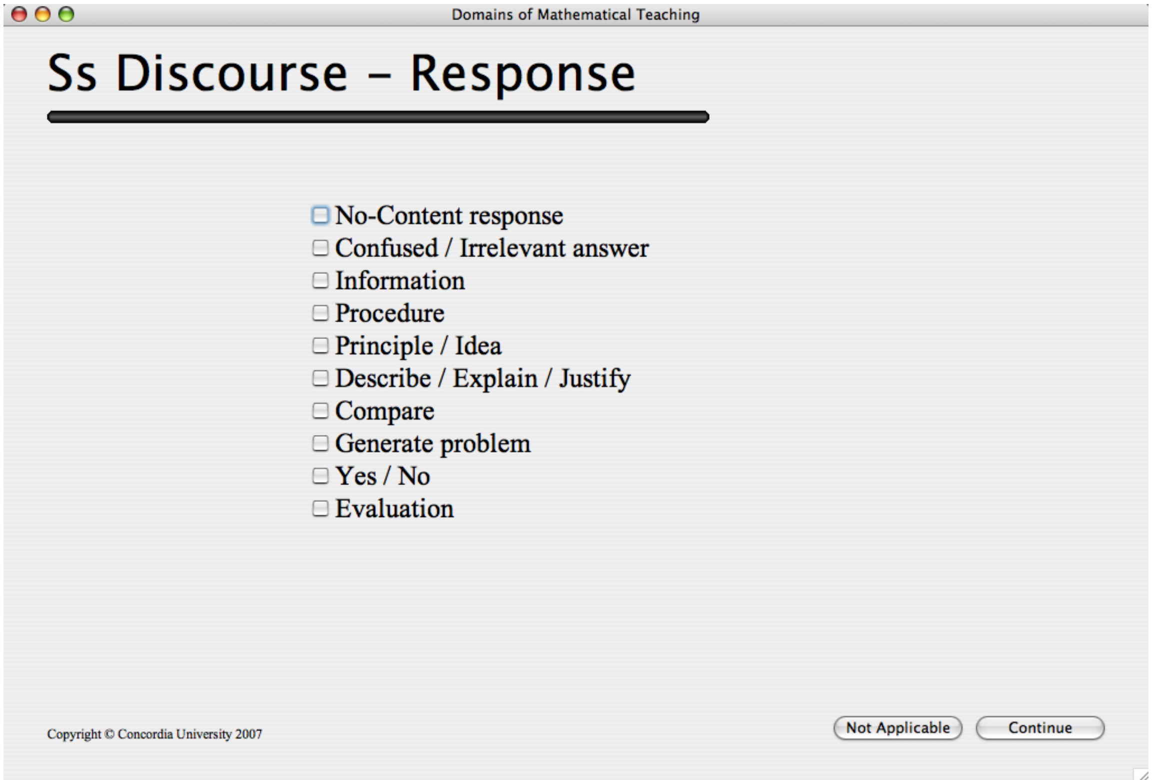

Domains of Mathematical Teaching
Non-Math Topic
Select the topic that characterizes the focus of activity
Language Arts (L...
Social Sciences
Art
Copyright © Concordia University 2007
Continue

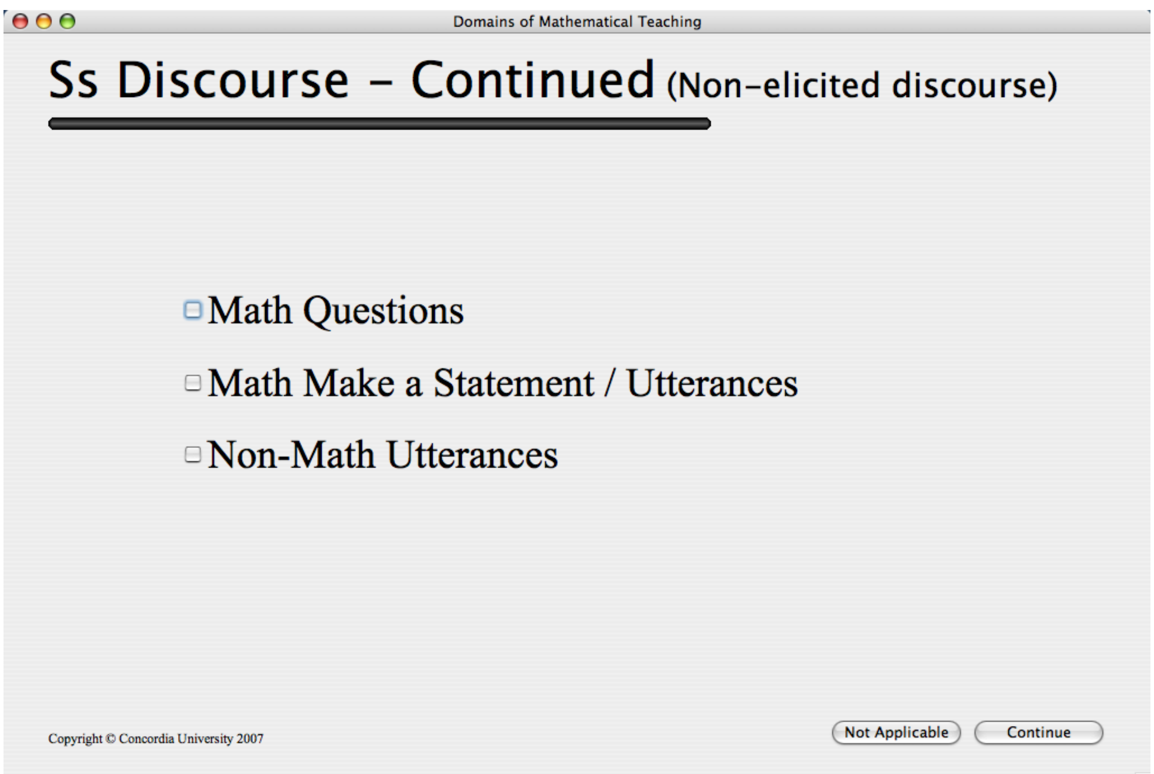

Domains of Mathematical Teaching
Math Test or Non–Test
Select one of the following:
Non-Test
Math Test
Copyright © Concordia University 2007
Continue

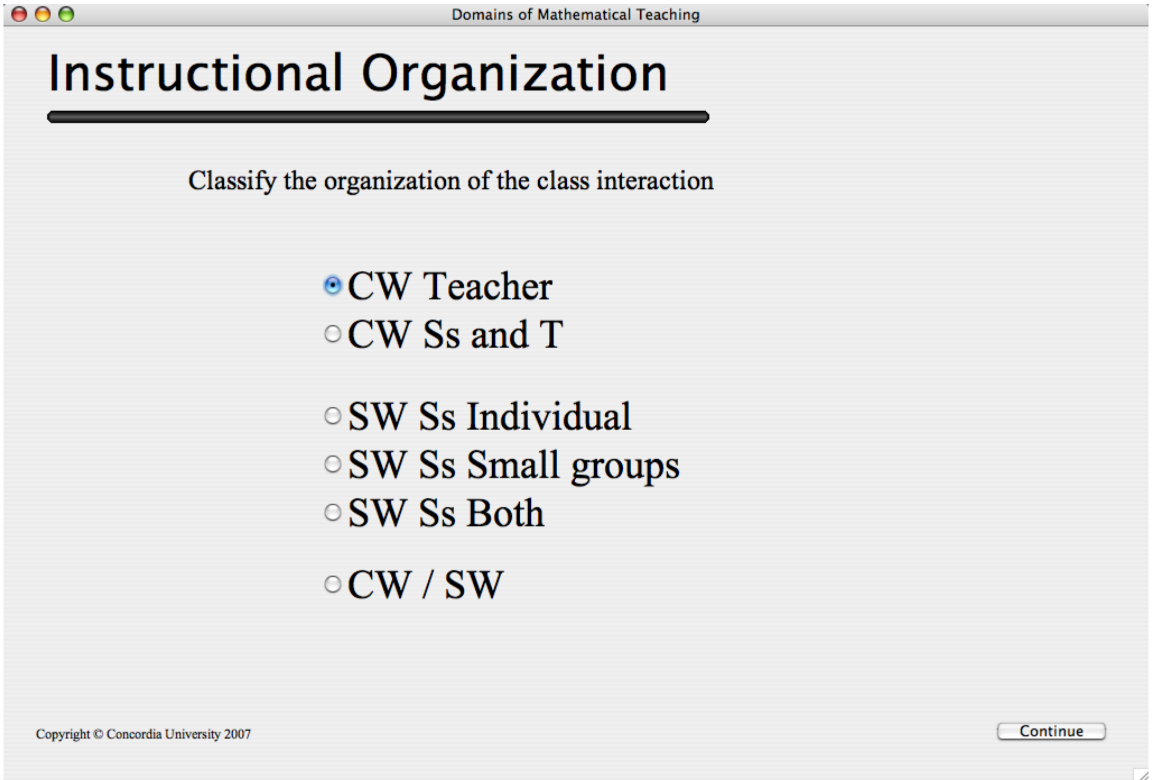

Domains of Mathematical Teaching
T Discourse (Intended to elicit Ss response)
Elicitation (Questions or Directions)
Content
Yes / No
Name / State
Information
Procedure
Principle / Idea
Describe / Explain / Justify
Compare
Generate Problem
Redirection
Evaluation
Other
Copyright © Concordia University 2007
Not Applicable
Continue

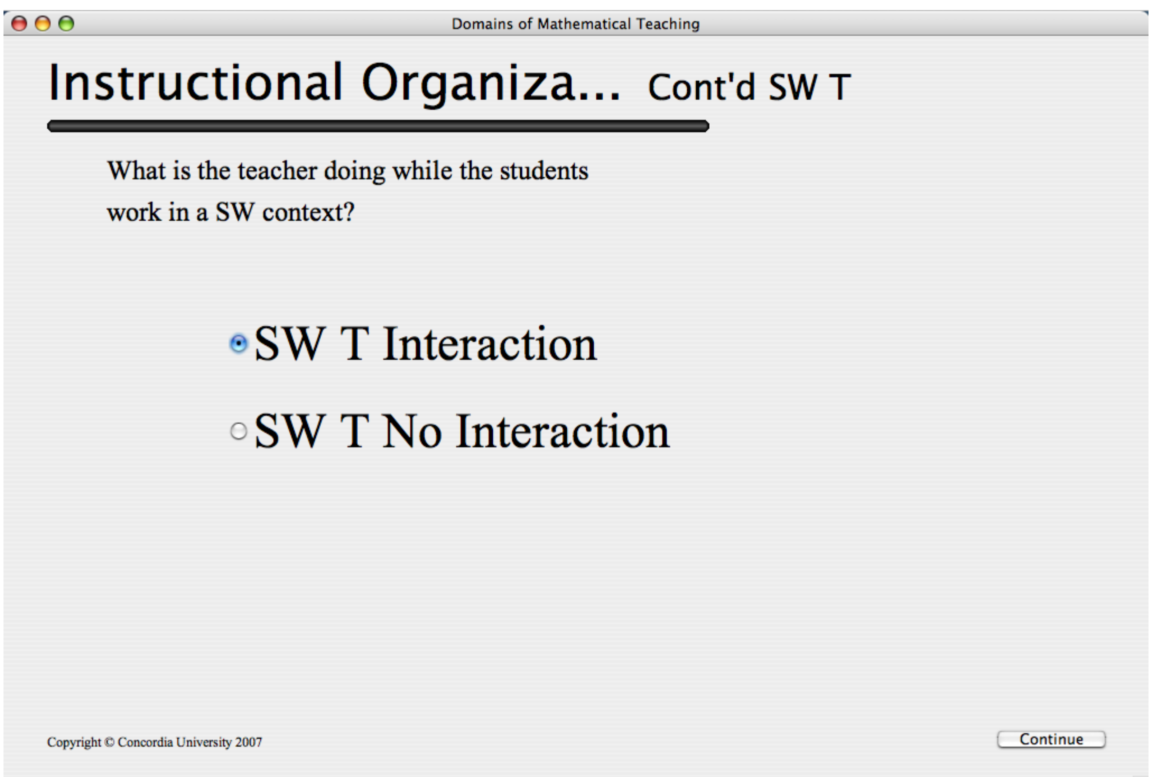

Domains of Mathematical Teaching
T Discourse – Direct Instruction (No Ss response Required)
Direct Instruction
Name / State
Information
Procedure
Principle / Idea
Describe / Explain / Justify
Compare
Expert Modeling
Copyright © Concordia University 2007
Not Applicable
Continue

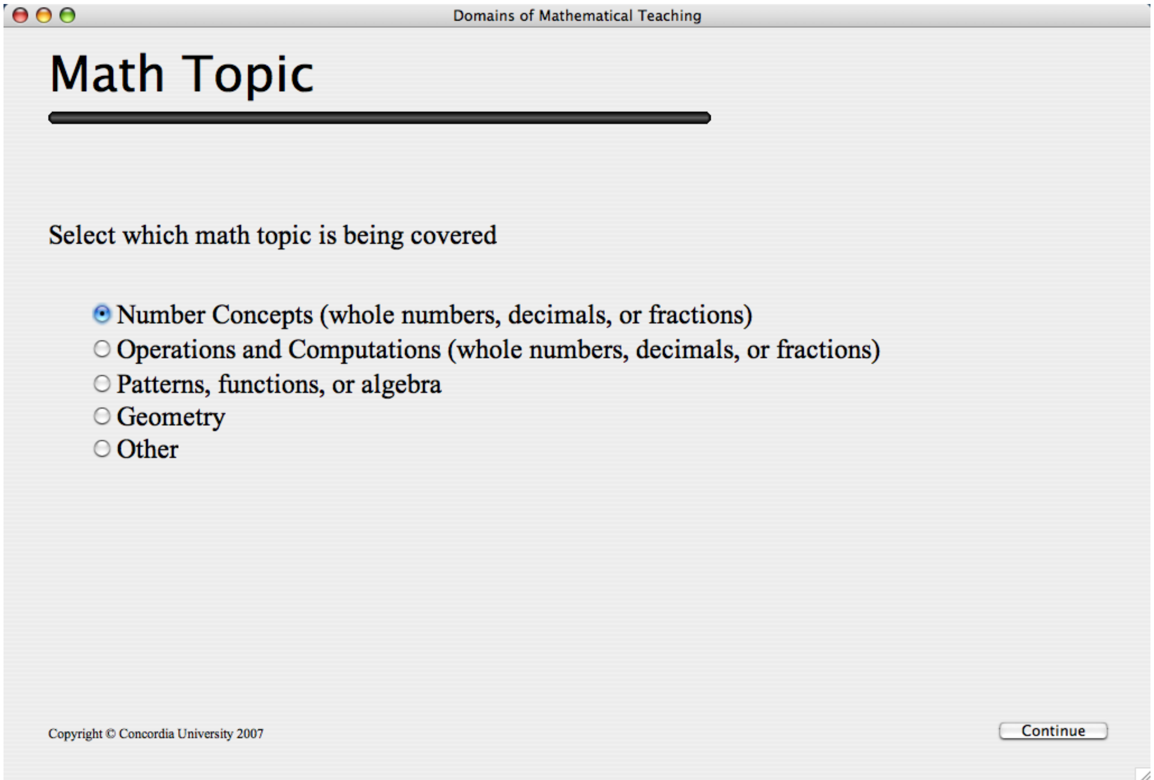

Domains of Mathematical Teaching
T Discourse – Managerial
Managerial Informational
Managerial Behavioural
Managerial Other
Copyright © Concordia University 2007
Not Applicable
Continue

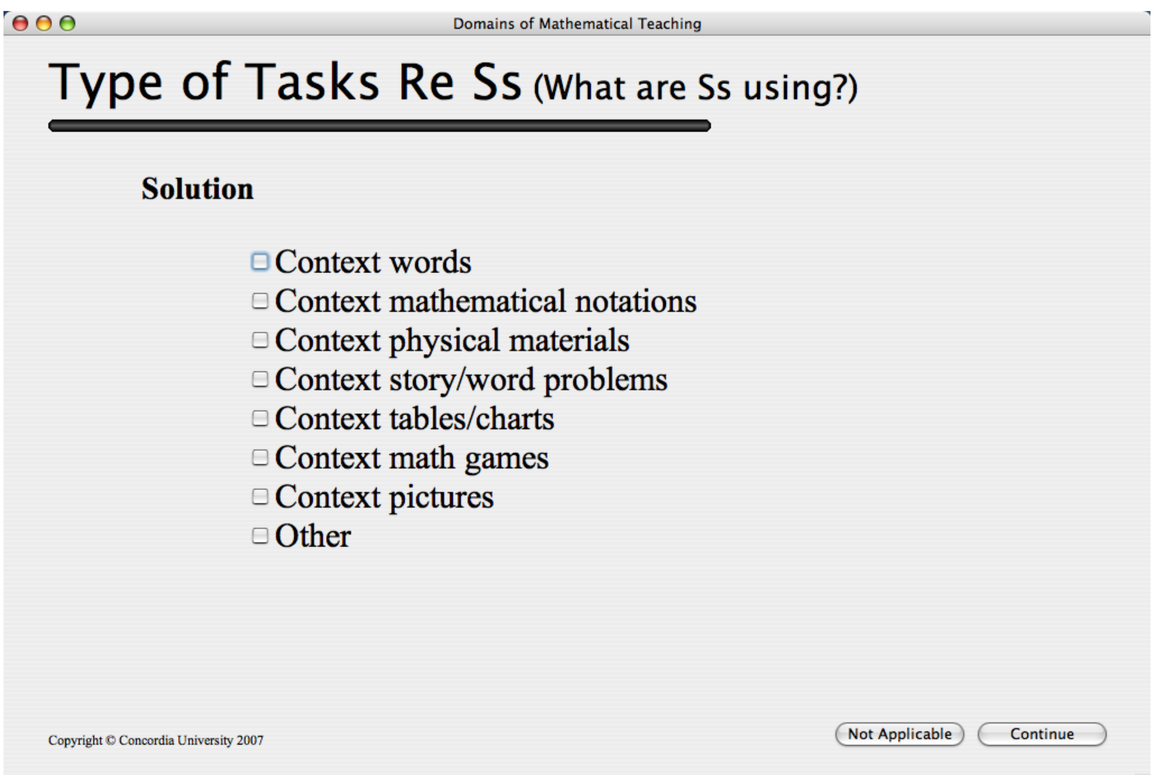

Domains of Mathematical Teaching
Ss Discourse – Response
No-Content response
Confused / Irrelevant answer
Information
Procedure
Principle / Idea
Describe / Explain / Justify
Compare
Generate problem
Yes / No
Evaluation
Copyright © Concordia University 2007
Not Applicable
Continue

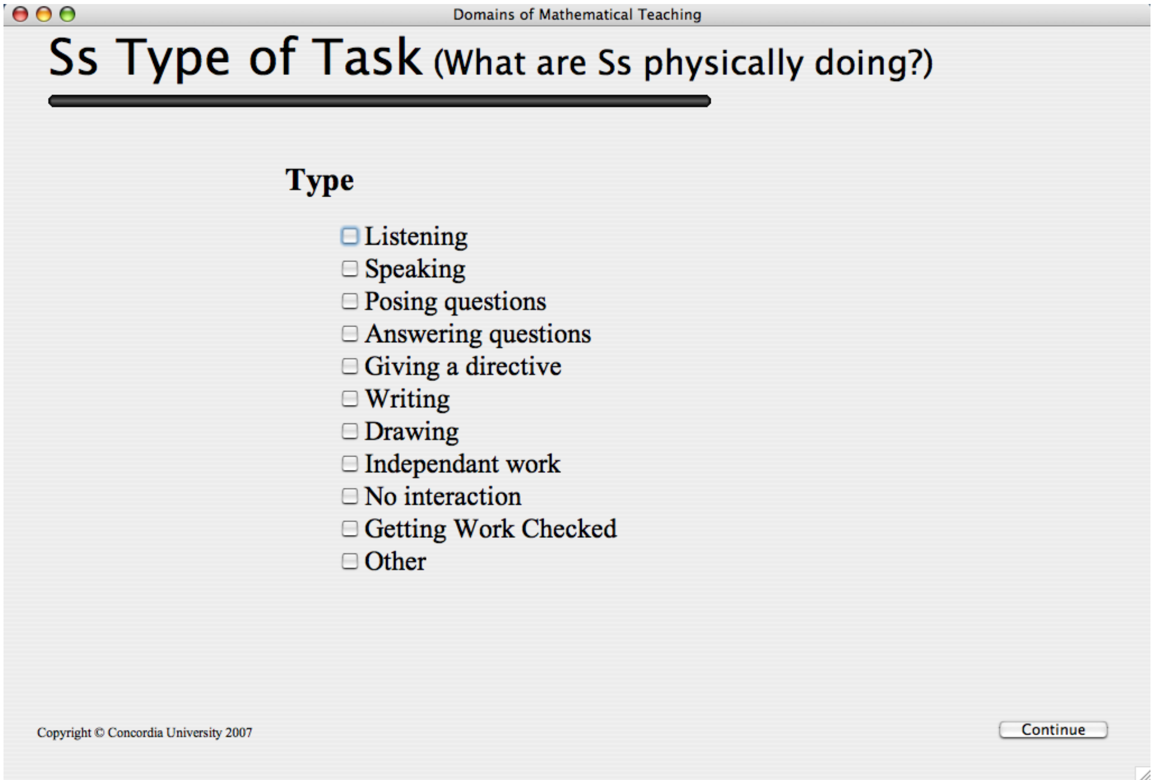

Domains of Mathematical Teaching
Ss Discourse – Continued (Non-elicited discourse)
Math Questions
Math Make a Statement / Utterances
Non-Math Utterances
Copyright © Concordia University 2007
Not Applicable
Continue

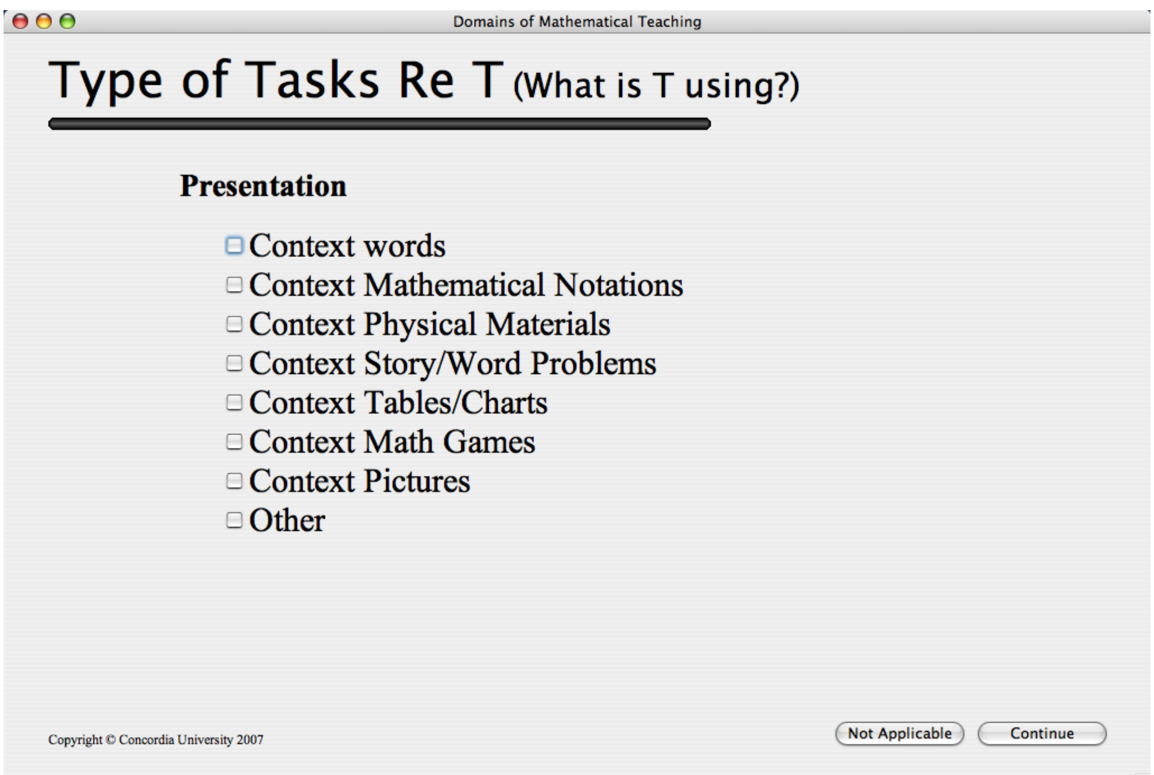

Domains of Mathematical Teaching
Instructional Organization
Classify the organization of the class interaction
CW Teacher
CW Ss and T
SW Ss Individual
SW Ss Small groups
SW Ss Both
CW / SW
Copyright © Concordia University 2007
Continue

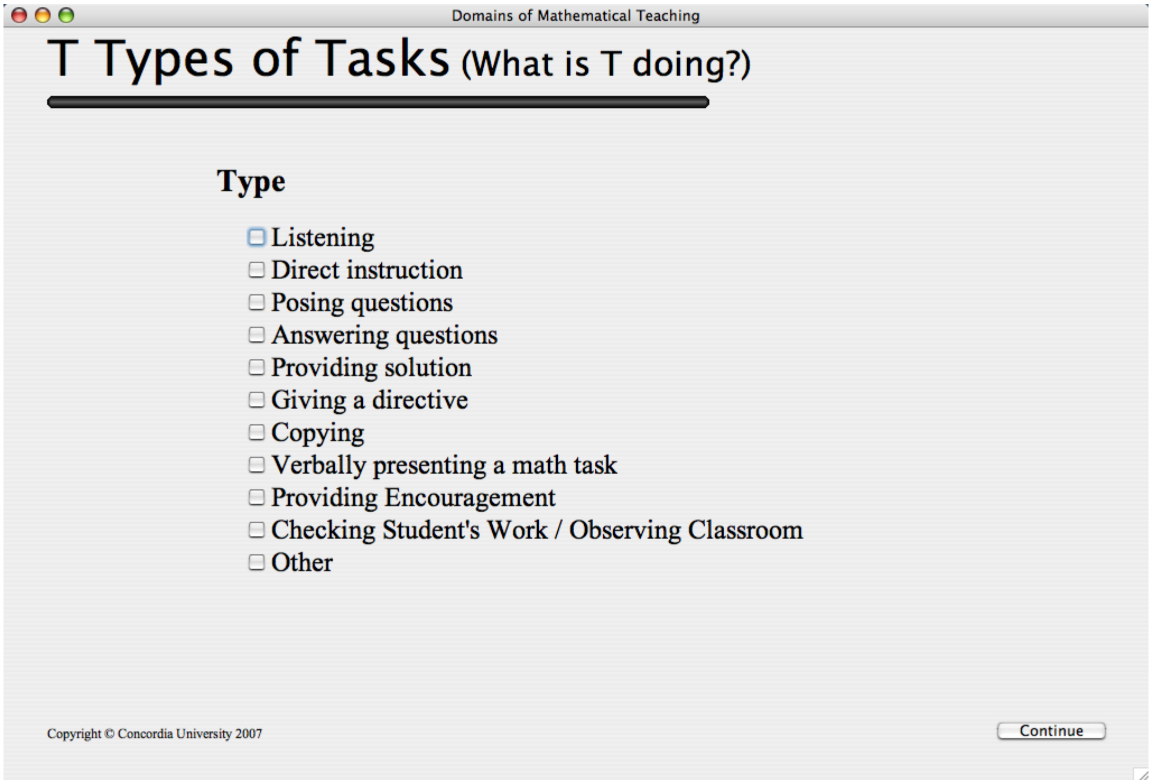

Domains of Mathematical Teaching
Instructional Organiza... Cont'd SW T
What is the teacher doing while the students
work in a SW context?
SW T Interaction
SW T No Interaction
Copyright © Concordia University 2007
Continue

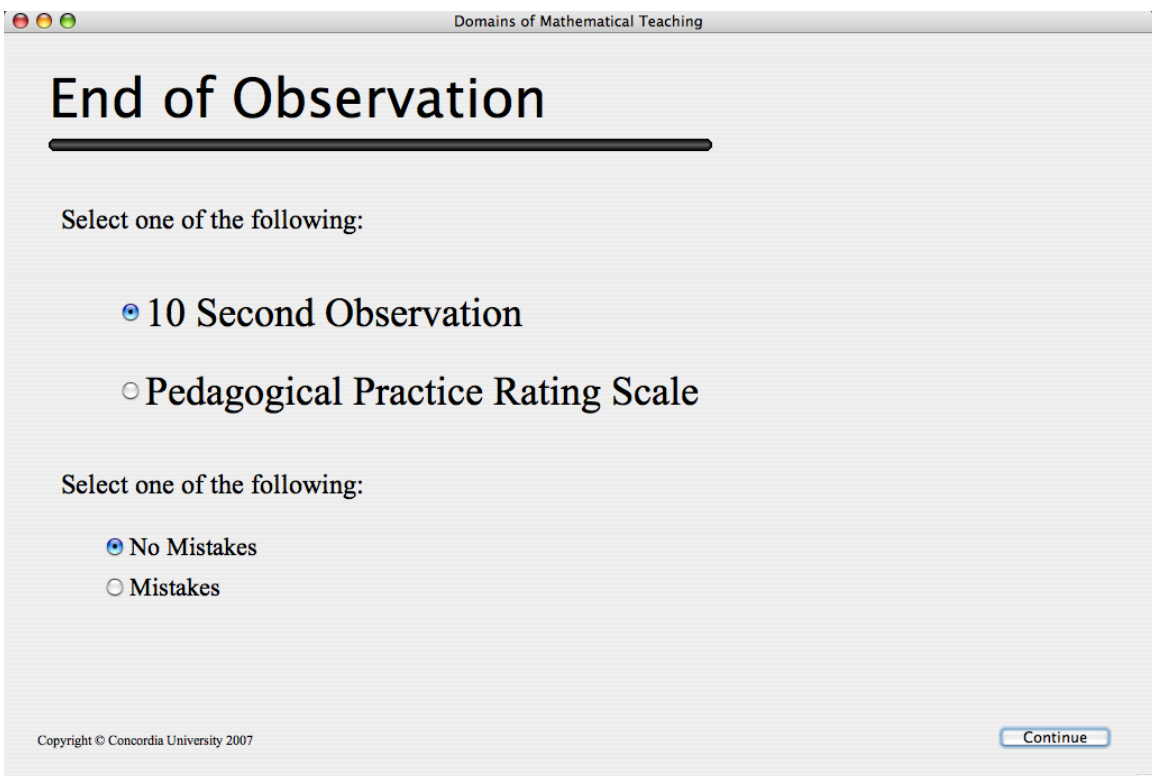

Domains of Mathematical Teaching
Math Topic
Select which math topic is being covered
Number Concepts (whole numbers, decimals, or fractions)
Operations and Computations (whole numbers, decimals, or fractions)
Patterns, functions, or algebra
Geometry
Other
Copyright © Concordia University 2007
Continue

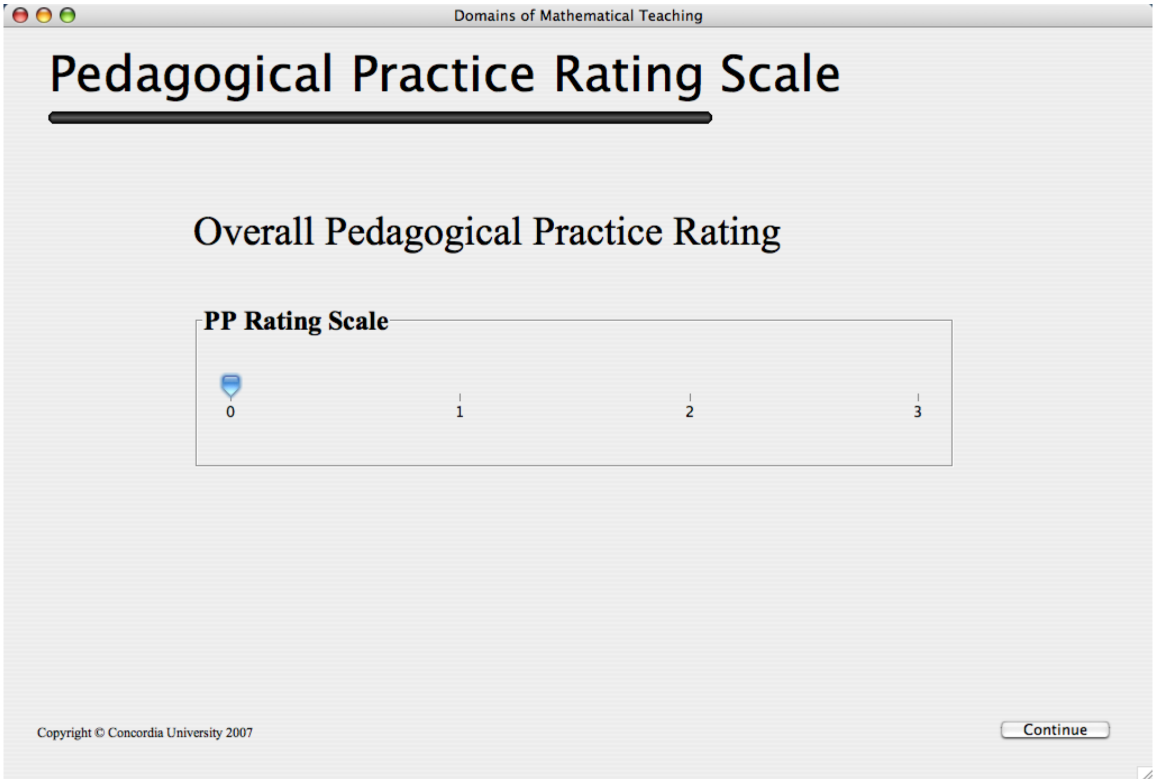

Domains of Mathematical Teaching
Type of Tasks Re Ss (What are Ss using?)
Solution
Context words
Context mathematical notations
Context physical materials
Context story/word problems
Context tables/charts
Context math games
Context pictures
Other
Copyright © Concordia University 2007
Not Applicable
Continue

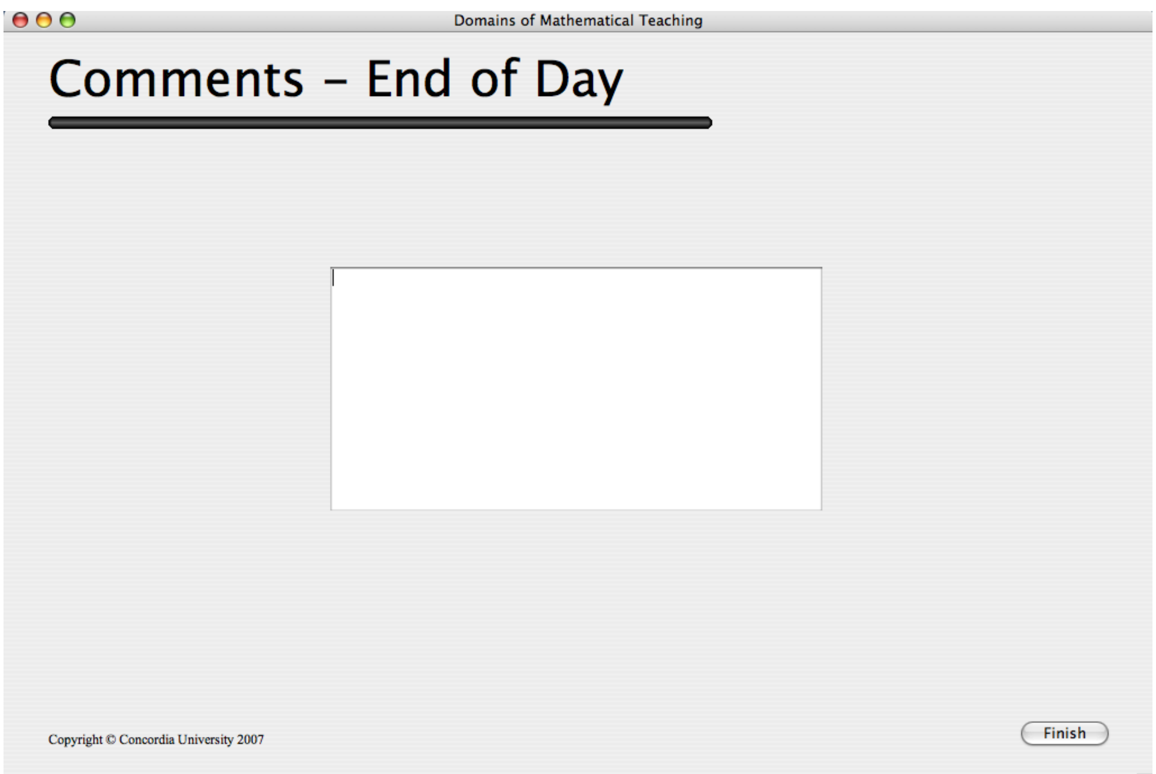

Domains of Mathematical Teaching
Ss Type of Task (What are Ss physically doing?)
Type
Listening
Speaking
Posing questions
Answering questions
Giving a directive
Writing
Drawing
Independant work
No interaction
Getting Work Checked
Other
Copyright © Concordia University 2007
Continue


Domains of Mathematical Teaching
Type of Tasks Re T (What is T using?)
Presentation
Context words
Context Mathematical Notations
Context Physical Materials
Context Story/Word Problems
Context Tables/Charts
Context Math Games
Context Pictures
Other
Copyright © Concordia University 2007
Not Applicable
Continue


Domains of Mathematical Teaching
T Types of Tasks (What is T doing?)
Type
Listening
Direct instruction
Posing questions
Answering questions
Providing solution
Giving a directive
Copying
Verbally presenting a math task
Providing Encouragement
Checking Student's Work / Observing Classroom
Other
Copyright © Concordia University 2007
Continue


Domains of Mathematical Teaching
End of Observation
Select one of the following:
10 Second Observation
Pedagogical Practice Rating Scale
Select one of the following:
No Mistakes
Mistakes
Copyright © Concordia University 2007
Continue


Domains of Mathematical Teaching
Pedagogical Practice Rating Scale
Overall Pedagogical Practice Rating
PP Rating Scale
0
1
2
3
Copyright © Concordia University 2007
Continue


Domains of Mathematical Teaching
Comments – End of Day
Copyright © Concordia University 2007
Finish

Appendix B

DMT Glossary

DMT Glossary of Terms

DMT Area: Classroom Topic

DMT Term	Definition	Example	Variable Name
I. Subject (Slide 4)			
Mathematics	The topic discussed in class addresses a math topic (see V. Math Topic)		Math
Non-math	The topic discussed does not address a math topic (see II. Non-math topic)		NonMath
II. Non-Math Topic (Slide 5)			
Language arts			LA
Social studies			SS
Art			Art
III. Math Test or Non-Test (Slide 6)			
Test	Students are taking a math test.		Test
Non-test	Students are not taking a math test.	Lectures, problem solving, activities, reviewing homework	NonTest

DMT Area: Teacher's Verbal Content

IV. Discourse Teacher

1. Elicitation/ Question (Slide 7)

A teacher utterance intended to elicit an immediate communicative response from student(s), including both verbal and nonverbal responses. Nonverbal: Nod, shaking head.
(TIMSS)

Categories of Elicitation Codes include:

A. Content
- **a. Yes/No**
- **b. Name/ State (i.e., information, procedure, principle/idea)**
- **c. Describe/Explain/Justify**
- **d. Compare**
- **e. Generate problem**

B. Redirection
C. Evaluation

Note that elicitations that apply to the Content and Evaluation categories primarily involve information directly concerned with mathematics, mathematical operations, or the lesson/task itself. Supply a quantity, identify a geometric shape, explain a mathematical procedure, define a math term, evaluate a mathematical answer.
(TIMSS)

Questions to consider when analyzing the content of the teacher's statement:

1. Does the content of the teacher's statement intend a verbal/nonverbal response?

2. Does the content of the teacher's statement address the subject of mathematics?

If you answer yes to both questions, use the following codes to classify the content. If you answer no to at least one of the questions, select "not applicable" (N/A) to continue.			
A. Content	**Definition**	**Example**	**Variable Name**
a. Yes/No	Any content elicitation that requests a simple yes or no response from student(s)	Does 4+3=7? Is this number larger than this one?	Ecy_n
b. Name/State Any content elicitation that requests a relatively short response (usually referring to labels of things). Also, an elicitation that requests a student to read a response (from a notebook, etc.) or that requests a student to choose among alternatives. Examples of statements that elicit a short response: Which group has more? How many more? So what's 4+3? What do I do to get the answer?			
b. Name/State Information	The teacher has asked a student(s) to state information that is associated with the topic of mathematics or a mathematics task but is not considered as procedural or conceptual knowledge.	What is 78-69? Which group has more? How many apples did Sally have?	Ecn_sinf
b. Name/State Procedure	The teacher has asked a student(s) to state knowledge of mathematical procedures (i.e., rules, properties, and principles of mathematics) associated with the topic of mathematics or a mathematics task.	What are the steps to solve 78 – 69?	Ecn_spro
b. Name/State Principle/Idea	The teacher has asked a student(s) to state knowledge of mathematical concepts (i.e., ideas) associated with the topic of mathematics or a mathematics task.	Why do 2+ 3 and 3+2 have the same answer?	Ecn_spm
c. Describe/ Explain/Justify	Any elicitation that requests descriptions of a mathematical object (rather than its label), explanation of a generated solution method (rather than an answer), or a reason something is true or not true. Requesting that a student describe/explain/justify their reasoning or decision making process.	Justify solution, explain method, describe alternative method or strategy, compare quantities, describe/ explain *what*, requesting a student to justify or evaluate his or her own work.	EC_D_E_J
d. Compare	An elicitation that requests the comparison of 2 or more strategies or procedures already completed	Can you tell me the difference between what you did and what Sam did?	ECcomp
e. Generate a problem	Students are asked to generate (come up with) their own stories or problems to illustrate math ideas, concepts, principles, operations	Generate a story to match a number sentence. Generate a problem to fit given constraints. Generate a number sentence to fit a word problem.	ECgenprb
B. Redirection	An elicitation that requests a student to modify his/her behavior, to acknowledge his/her participation in some current activity, to recall specific classroom procedures or rules, or to gain students' attention. This category does NOT involve mathematical content. Rather, the student's behavior is redirected to the task	Are you listening? Tell me what Johnny just said? What are you supposed to be doing?	Rredir

	at hand. To distinguish this code from Managerial Behavioral, the redirection of the students' behavior requires a *communicative (verbal or nonverbal)* response from the student. If the student has to just respond by performing the behavior without communicating anything then code **Managerial Behavioral**. This code is often associated with the behavior of giving a directive.		
C. Evaluation	An elicitation that requests a student(s) to evaluate another student's answer, response, strategy, etc. Not only involves evaluating the accuracy of an answer, but can also involve evaluating another student's solution strategy. Listen for words such as: best, better, coolest, smartest, neatest. This differs from Compare in that the student is not elicited to compare more than one solution or strategy, but rather involves a student being asked to make a judgment of another student's solution and/or strategy. Teacher's request to evaluate another student's answer can also involve judging whether the answer is correct or incorrect (e.g., thumbs up if the answer is correct or thumbs down if the answer is incorrect)	Which strategy did you like best, why? Does that strategy work?	EEval
Other	An elicitation that does not fit into any of the above categories, including all forms of conversational repair. When an elicitation occurs in the middle of a student's long response, it may be coded as Other when it is obvious that the teacher does not intend to terminate the response but to clarify a part of response.	Did you bring your book with you today?	EOther
N/A	The content of the statement was not an elicitation and/or it was not related to the topic, teaching, or learning of mathematics.		E_NA

2. Direct Instruction (Slide 8)
A teacher utterance intended to provide information to the student(s). Does not require communicative or physical response from students. The teacher did not elicit a response from the students and the statement content was mathematical in nature.
(TIMSS)

Categories of Direct Instruction Codes include:
A. Name/State (information, procedure, and principle)
B. Describe/Explain/Justify
C. Compare
D. Expert Modeling

Note that direct instruction involves information directly concerned with mathematics, mathematical operations, or the lesson itself. Supply a quantity, identify a geometric shape, explain a mathematical procedure, define a math term, evaluate a mathematical answer.
(TIMSS)

Questions to consider when analyzing the content of the teacher's statement:

1. Does the content of the teacher's statement intend a verbal/nonverbal response?
2. Does the content of the teacher's statement address the subject of mathematics?

If you answer no to question 1 and yes to question 2, use the following codes to classify the content. If you answer no to both questions, select "not applicable" (N/A) to continue.

A. Name/State	**Definition**	**Example**	**Variable Name**
A. Name/State Information	The teacher describes features of a subject/problem.	The goal of problem solving	Din_sinf
A. Name/State Procedure	The teacher states a procedure (i.e., rules, properties and principles of mathematics) to help the students understand a topic/problem. No explanation of why is provided – when an explanation is given, code as D/E/J.	To divide a whole number by a fraction, you inverse the fraction (the divisor) and multiply the whole number by the reciprocal.	Din_spro
A. Name/State Principle/Idea	The teacher states a concept to help the students understand a math topic/problem. No explanation of why is provided – when an explanation is, given code as D/E/J.	The concept of place value explains why certain partial products are powers of 10.	Din_spm
B. Describe/ Explain/Justify	The teacher provides information and explains/justifies notions addressed in the information stated.	The distributive property explains why you multiply a number to all digits in a number in accordance with their place value.	DI_D_E_J
C. Compare	The teacher compares responses or information stated by students or from some other referent (e.g., textbook). If the teacher is making a comparison to support a D/E/J, code both.	To answer $3 + \square = 8$, Jim counted how many cubes he added to 3 to get to 8. Tammy, on the other hand, subtracted 3 from 8 in her head.	DI_com
D. Expert Modeling	The teacher is verbally modeling a concept or procedure in accordance with how she or he conceptualizes it. The teacher may pose a question that is intended for her/himself to answer. Code during CW organization when teacher provides the solution.	So first I add the values in the ones place and then…	DIExpMod
N/A	The teacher is not providing any direct instruction.		DI_NA

3. Managerial (Slide 9)
A direction that solicits or prohibits students' physical activities except for mathematical tasks.
"All right, get started," "Open your books to page 14," or "Leave some space between that." (TIMSS)
Note that, unlike Elicitation and Direct Instruction, Managerial content is directly concerned with classroom events (including mathematical tasks).

	Definition	Example	Variable Name
Informational	The teacher is uttering information to give direction to the students. Reading or re-reading a problem for the students to do. Also, if teacher provides a solution during SW organization, code here. E.g.: "That's right" vs. reinforcement (to be coded as **Managerial Other)** "Great!" To help distinguish from **Managerial Behavioral**, within the context of students engaging in or teachers presenting math tasks, the teacher's speech content addresses *what* needs to be done.	The test will cover chapters 1 to 4.	TDOManIn
Behavioral	The teacher is uttering information in order to direct student behavior. Do not code if the behavior is directed by the problem (code Managerial Information). That is, if a teacher is reading or re-reading or clarifying a problem and the problem tells you what to do (e.g., you need to draw the butterflies or circle the number of lines in the tree), then it is not the teacher that is directing the students' behavior. To help distinguish from **Managerial Informational**, within the context of students engaging in or teacher presenting math tasks, the teacher's speech content addresses *how* to do something. When a teacher suggests a way to solve the problem that is not part of the directions (e.g., to solve 4 + 2 the teacher says "Use the blocks"), then this code applies.	Go and get the materials in your cubbies.	TDOManBe
Other	The teacher's utterances cannot be described in terms of having any elicitation, direct instruction, or managerial content. Encouragement or positive reinforcement goes here.	E.g.: "Great!" vs. feedback (to be coded as **Managerial Informational)** "That's right"	TDOOther
N/A	The content of the teacher's statement does not fit this category		TDO_NA

DMT Area: Students' Verbal Content

V. Discourse Student			
Students' Elicited Responses (Slide 10) Student responses that have occurred because the student(s) was elicited to communicate verbally or nonverbally. Codes are applicable for students in the spotlight (during CW) or all students speaking together (during CW) or students speaking to the teacher during SW.			
	Definition	**Example**	**Variable Name**
No-Content response	The student does not provide a verbal response to the teacher's elicitation. Includes a refusal to answer or an inability to answer. Also can be coded in conjunction with Teacher's Elicitation Other. In this case, the student was elicited to communicate a response, but the content of this response was unrelated to mathematical content.	Student shrugs "I don't know"	SRESncr
Confused/ Irrelevant answer	A student utterance not intended to elicit any immediate response from the teacher or from other students, but was made in response to an elicitation from the teacher. In this case, the student's statement comprised information that was not related or relevant to the question. This code is NOT concerned with the accuracy of the statement's content (wrong answer). The student's statement may be an indication that he or she misunderstood the question or task.		SRESCoir
Information	A student utterance not intended to elicit any immediate response from the teacher or from other students, but was made in response to an elicitation from the teacher. In this case, the student's statement comprised mathematical information that does not pertain to mathematical concepts, procedures, or D/E/J.		SRESInfo
Procedure	A student utterance not intended to elicit any immediate response from the teacher or from other students, but was made in response to an elicitation from the teacher. In this case, the student's statement comprised information mathematical information that pertains to mathematical procedures (i.e., rules, properties, and principles of mathematics).		SRESProc
Principle/Idea	A student utterance not intended to elicit any immediate response from the teacher or from other students, but was made in response to an elicitation from the teacher. In this case, the student's statement comprised mathematical information that pertains to mathematical concepts.		SRESPrin

Describe/ Explain/Justify	A student utterance not intended to elicit any immediate response from the teacher or from other students, but was made in response to an elicitation from the teacher. In this case, the student's statement comprised mathematical information that pertains to describing/explaining/justifying mathematical reasoning.		SRESdej
Compare	A student utterance not intended to elicit any immediate response from the teacher or from other students, but was made in response to an elicitation from the teacher. In this case, the student's statement comprised information that compared at least two solutions or strategies.		SREScomp
Generate problem	A student utterance not intended to elicit any immediate response from the teacher or from other students, but was made in response to an elicitation from the teacher. In this case, the student's statement comprised mathematical information that pertains to generating a problem.		SRESgen
Yes/No	A student utterance not intended to elicit any immediate response from the teacher or from other students, but was made in response to an elicitation from the teacher. In this case, the student's statement comprised mathematical information that pertains to a yes or no answer that is related to MATHEMATICAL CONTENT only.		SRES_y_n
Evaluation	A student utterance not intended to elicit any immediate response from the teacher or from other students, but was made in response to an elicitation from the teacher. In this case, the student's statement comprised mathematical information that pertains to judging or evaluating another student's solution strategy.		SRESEval
N/A	The student(s) was not elicited to speak.		SRES_NA

Students' Nonelicited Responses (Slide 11) Statements uttered by students who were not elicited to communicate by the teacher Codes are applicable for students in the spotlight (during CW) or all students speaking together (during CW) or students speaking to the teacher during SW.			
	Definition	**Example**	**Variable Name**
Math Questions	Students ask a content- or task-related question, without being prompted, in response to a statement or task that was not intended to procure a mathematical question.	How many shirts does the problem state? Can you explain why that works?	SDISCmq
Math Statements	Students state a content- or task-related utterance, without being prompted, in response to a statement or task that was not intended to	This group has more cubes than we do.	**SDISCmut**

	procure a mathematical statement. Public thinking or mathematical reasoning without being prompted to do so.		
Non-math utterance	Students state a non-content- or non-task-related utterance, without being prompted, and in response to a statement or task that was not intended to procure a statement. Public thinking without being prompted to do so.	"Woohoo!" "Can I go to the bathroom?"	**SDISCnmu**
N/A	The student(s) did not make a nonelicited statement.		**SDISC_NA**

DMT Area: Classroom Organization

VI. Instructional Organization (TIMSS; Slide 12)

Defining Class Work (CW)
Class Work: the teacher is working with all or most of the students in a whole-class situation; the type of talk is predominantly public, that is, the audience is the whole class.

For example: Teacher is lecturing or demonstrating to the entire group (or most); student explaining a strategy to the entire group (or most).
TIMSS

	Definition	**Example**	**Variable Name**
CW T	Class Work Teacher: within a *whole-class situation*, the present activity involves the teacher as the primary speaker	Setting-up physically or giving directions in preparation for the upcoming lesson	CW1
CW Ss and T	Class Work Students and Teacher: within a *whole-class situation*, the present activity involves both student and teacher leading the class together	Working on tasks, sharing solutions, correcting homework, etc.	CW2

Defining Seat Work Students (SWS)
Seat Work Students: a period of time during the lesson when students work independently on assigned tasks, either alone or in small groups. The type of talk is predominantly private, although there may be instances of public talk as well (as when the teacher makes an announcement to the whole class).

Example: The beginning of seat work is usually marked by: a) a teacher announcement that students should begin their work; b) a period of silence after the teacher provides necessary information to students; and 3) students actually start working.
TIMSS

	Definition	**Example**	**Variable Name**
SW Individual	Seat Work Individual: Students are engaged in independent and individual work on assigned tasks (independent of the teacher, and individually)	Students work alone at their own desks with little *math-related* interaction taking place	SWSs3
SW Small Groups	Seat Work Small Groups: Students work independently in small groups (2 or more) on assigned tasks (independent of the teacher)	Students work in groups of two or more, and interact *mathematically* around content	SWSs4

SW Both	Seat Work Both: Students work independently (of the teacher) on assigned tasks, some individually and others in small groups.	Any organizational combination of the above two types	SWSs5
CW/SW	Class Work/Seat Work Combination: Some students work independently on assigned tasks while the rest of the class works with the teacher.	Most students watch the teacher demonstrating while a few work independently to complete other work	CW_SW

Defining Seat Work Teacher (SWT; Slide 13) Seat Work Teacher: What is the teacher doing while students work independently on tasks? (HAREM)			
	Definition	**Example**	**Variable Name**
SW T Interaction	Seat Work Teacher Interaction: The teacher interacts with students as they work on assigned tasks.	Teacher Interacts with individuals or small groups of students: circulating around the room, checking progress, posing/answering questions, etc.	SWT7
SW T No Interaction	Seat Work Teacher No Interaction: The teacher does not interact with students as they work on assigned tasks.	Teacher remains seated at his/her desk, is busy with other non-math related tasks	SWT8

DMT Area: Mathematics Topic

VII. Math Topic (SII; Slide 14) - What topic in mathematics is the goal of the lesson during the observed time slice?			
	Definition	**Example**	**Variable Name**
Number Concepts	**Number concepts** refer to all noncomputational work on whole numbers, decimals, or fractions. This includes writing, reading, or *naming numbers; counting*; *comparing* or *ordering quantities*; understanding *place value*; relationships between fractions and decimals; and estimating. For whole numbers only, it also includes *properties of numbers* (such as odd and even, prime and composite, square numbers), and factors, multiples, or divisibility. For fractions, it also includes work on the meaning of a fraction, on equivalent fractions, and on simplifying fractions. Do not record work on computation, basic facts, or patterns here unless that work was accompanied by a significant piece of work on a number		NumCon

	concept topic as well.		
Operations	**Operations** refer to work on *addition, subtraction, multiplication, and division*. Include any work on meanings of these operations, *understanding and developing competency with basic facts, multi-digit computation with whole numbers, and any computation with decimals or fractions*. Also include learning about the properties of operations. Do not record operations with negative numbers here – instead code as Other.		OperComp
Patterns, functions, or algebra	**Patterns, functions, or algebra** includes work on *organizing objects by size, number, or other properties into groups, categories, or lists; different types of patterns; generalizing patterns; using symbols to express unknown and variable quantities; and understanding and using formulas*. A function is a relation that expresses how one quantity or variable changes with respect to another.		PatFncAl
Geometry	**Geometry** includes work on area and perimeter, shapes, properties of shapes, angles, lines, and spatial reasoning. Geometric concepts and designs.		Geom
Other	**Learning about money**, **telling time**, or **reading a calendar:** Include in this category only instruction about features of money, time, or the calendar – not instruction that merely uses these to help students practice facts or procedures. **Representing or interpreting data:** Include in this category work on creating or using tallies, tables, graphs or charts to represent data; making inferences or drawing conclusions from data; and lessons on mean, median, or mode. **Measurement:** Include in this category instruction about length, weight, volume or capacity, units of measurement, and systems of measurement (e.g., metric, English). **Probability:** Includes work on the concept of probability, estimating or calculating the likelihood of different outcomes. **Percent, ratio, or proportion:** Work with concepts or applications of percents, ratios, or proportions. **Negative numbers:** Work that comprises the meaning of negative numbers or computations involving negative numbers. Other is also coded when the topic is not clear or at the end of the day when the topic is no longer being addressed but math class is		Other

	still in session. Problem solving when the topic is not clear or involves one of the topics coded in other and another topic (e.g., started problem solving and the topic of the problem was number concepts but the final problem was measurement; as soon as one child was observed solving the problem that addressed measurement, Other was coded to reflect that both topics have been covered – in this case specify the topics and overall events in the classroom in the Comments page in order to clarify what the "other" refers to.		

DMT Area: What are the Students Using?

VIII. Type of Task Regarding Students' Solution (SSOL; Slide 15)
What contextual features are the students using to solve a problem or perform a task.
(H & W, SII, & HAREM)

Coding Rules on which students to focus on:

During **SW**, focus on what students are using in general.

Code only what students are physically touching (e.g., pictures) or what you hear come from them (i.e., words).

When the students are working on separate tasks (e.g., groups of students are engaging in different activity centers), code all of the contextual features that may apply. The one exception is **physical materials –** because fingers fall under this code, technically students could always have access to this. For this reason, select this code when you see at least one student using a physical material.

	Definition	**Example**	**Variable Name**
Words	**Words:** Students are using words to solve a problem or performing task. Included is way students verbalize (use words) to express mathematical notations (e.g., counting out loud) when mathematical notations are not being written.	Speaking about the task, writing number words, writing out a story to help solve the problem "Let's count together, one, two, three…"	SSOLWrds
Mathematical Notations	**Numbers or symbols**: Mark this category if the student used numbers and/or symbols to work on the task. Include in this category worksheets, flashcards, and other purely symbolic means by which students might learn about representations, facts, or procedures. If the worksheet or flashcard includes only pictures or diagrams, however, record this as Pictures. Note: Includes written notations only – do not code if notations are verbally expressed only.	The student uses the numeral 5 to represent the idea of five objects. The student works on addition with fractions using only numbers and symbols.	SSOLNot
Physical	**Concrete materials**: Mark this category if the	Counted concrete objects	SSOLPhys

Materials	student used *mathematical* materials (e.g., pattern blocks, fraction pieces, bean sticks, fingers vs. scissors) to work on the task.	or used pattern blocks	
Story/word problems	**Story/word problem:** Mark this category if the students are creating a fictional story to solve a task or demonstrate its solution using contextualized situations. This category also includes both situations developed from classroom life and word problems found in curriculum materials or written by the teacher or students.	Story problems about needing to find change at the school store, comparing the height of two third-graders, or doubling fractional teaspoons in a recipe.	SSOLStry
Tables/Charts	**Tables or charts**: Mark this category if the student used tallies, tables, or charts to work in the focal topic category. The student might have constructed tables or charts, or they might have been available in curriculum materials or other mathematics materials.	Table of students' favorite fruits	SSOLTble
Math Games	**Math games:** Students are solving a problem via participating in a game. Math games have features of a game: there can be a winner and/or performance can be scored.	Math bingo	SSOLGame
Pictures	**Pictures or diagrams**: Mark this category if the student used pictures or diagrams to work in the focal topic category. The student might have constructed pictures or diagrams, or they might have been available in curriculum materials or other mathematics materials. If the student worked with number lines or graphs, record that here. However, if the diagram was a table or a chart, mark that as Table/Charts instead.		SSOLPix
Other	Students are using other materials or features to solve a problem or perform a task that is not listed above		SSOLOthr
N/A	Students are not using anything to perform a task or solve a problem		SSOL_NA

DMT Area: What are the Students Physically Doing?

IX. Type of Task for Students (STYP; Slide 16)
What behaviors are the students displaying?
(SII & HAREM)

Coding Rules for which students should be coded for this section:

During CW, all codes apply to all students.

During SW, first 4 codes apply only to students interacting with the teacher. The remaining codes apply to what all the students are doing in general. This is particularly important with respect to the speaking codes since this rule makes it easier to objectively code their speech content.

	Definition	Example	Variable Name
Listening	Students are listening to the teacher.	Listening to teacher's	STYPLisn

	During CW, the teacher needs to be speaking to the class or an individual student that is in the spotlight. During SW, the teacher needs to be speaking with the student with whom he or she is interacting.	lecture	
Speaking	Students are uttering words. Do not code if speech content involves posing a question or answering a question, which should be recorded in the appropriate code below.		STYPSpk
Posing a question	Students are asking questions to the teacher or to other students		STYPPose
Answering questions	Students are responding to a question that was asked either directly to them or to the class at large.		STYPAns
Giving a directive	Students are *managing* an activity or situation, but no math content is involved here. This must occur in a group setting with at least one other student.	Telling each person in a group what role to take when solving the problem: "You take the notes and I'll look in the book."	STYPWrit
Writing	Students are writing.		STYPWrit
Drawing	Includes the behavior of drawing pictures.		
Independent work	Students are working independently but may intend to interact with fellow students or the teacher	This refers to a seat work context, where students work independently of the teacher and where interaction with peers is occurring or is intended (by the teacher) to occur.	STYPInd
No interaction	Students are working independently but are not interacting with any students or the teacher during this time.	This refers to a seat work context, where students work independently of the teacher and where interaction with peers is not occurring and is not intended (by the teacher) to occur.	STYPNInt
Getting Work Checked	Includes showing the teacher their work either because they went to show the teacher or the teacher came to see them. In all cases, the student has to be engaging in the behavior of *showing* their work.		STYPCwrk
Other	Students are demonstrating behaviors that are not listed above.		STYPOthr

DMT Area: What is the Teacher Using?

X. Type of Task Regarding Teacher Presentation (PRES; Slide 17)
What *contextual features* is the teacher *using to present* or demonstrate a task, concept, procedure or problem (H & W, SII, & HAREM)

Coding Rules:

This section is to be coded when the teacher is actually presenting a task. Some tasks require the teacher

to present several problems that fall under the same type of task; code this each time the problem changes (e.g., show me 100; show me 99). When the teacher is simply re-stating the entire problem or parts of the problem (i.e., to clarify), code N/A and code behavior as verbally presenting the task if applicable.			
	Definition	**Example**	**Variable Name**
Words	**Words:** Teacher is using words, written or spoken, to present the task.	Writing on the blackboard; describing a feature of the task; reading a problem	PRESwrds
Mathematical Notations	**Numbers or symbols**: Mark this category if the teacher is using numbers and/or symbols to present something to the students. Includes worksheets, flashcards, and other purely symbolic means by which students might learn about representations, facts, or procedures. If the worksheet or flashcard includes only pictures or diagrams, however, record this as Pictures. When geometric shapes are used to represent geometric concepts, choose this code. If, however, geometric shapes are used simply as pictures or counting objects, code as Pictures.	The teacher uses the numeral 5 to represent the idea of five objects. The teacher demonstrates adding with fractions using only numbers and symbols.	PRESnota
Physical Materials	**Concrete materials**: Mark this category if the teacher presents materials (e.g., pattern blocks, fraction pieces, bean sticks, fingers) to work on the task and if those materials are not intended to be used in a game format (for materials used for the purpose of a game, code as Math Games).	The teacher counts concrete objects or shows how fractions are equivalent using pattern blocks or diagrams to represent same-sized but differently named areas.	PRESphys
Story/word problems	Mark this category if the teacher is creating a fictional story to present a math concept or demonstrate its solution using contextualized situations. This category also includes both situations developed from classroom life and word problems found in curriculum materials or written by the teacher or students.	Story problems about needing to find change at the school store, comparing the height of two third-graders, or doubling fractional teaspoons in a recipe.	PRESstry
Tables/Charts	**Tables or charts**: Mark this category if the teacher presents a task using tallies, tables, or charts to work in the focal topic category. The teacher might have constructed tables or charts, or they might have been available in curriculum materials or other mathematics materials.	Table of students' favorite fruits	PREStble
Math Games	Teacher is using game materials to present a task	Bingo cards; other manipulatives intended for use in a game situation	PRESgame
Pictures	**Pictures or diagrams**: Mark this category if the teacher is using pictures or diagrams to work in the focal topic category. The teacher might have constructed pictures or diagrams, or they might have been available in curriculum materials or other mathematics materials. If the teacher worked with number lines or graphs, record that here. If the		PRESpix

	diagram was a table or a chart, however, mark in Tables/Charts instead.		
Other	The teacher used something other than what has been listed to demonstrate or present a task to the students		PRESothr
N/A	The teacher did not present or demonstrate a task or problem to the students	PRES_NA	

DMT Area: Type of Knowledge Associated with the Task

XI. Problem Solving Scale (TPS; Slide 18)	**Variable Name**
Problem-Solving Scale **This scale rates the extent to which the task being used addresses mathematical procedures and/or concepts. 0 = only addresses procedure; 3 = only addresses concepts.** **0, 1, 2, 3, or N/A (4)**	**T_PS0;** **T_PS1;** **T_PS2;** **T_PS3;** **T_PS_NA**
XII. Factual Scale (TFac; Slide 19)	
This scale rates the extent to which the teacher is integrating several facts or using an isolated fact to demonstrate or present a math task or problem. **0, 1, 2, 3, or N/A (4)** **THIS WAS NEVER CODED DURING THE PILOT. IT IS TOO DIFFICULT TO CODE (CODERS DID NOT ALWAYS HAVE INFORMATION OF THE TASKS USED DURING THE LESSON) IN A 10-SECOND TIME SLICE. IF THE CODERS HAD ENOUGH KNOWLEDGE OF THE TASKS TO DETERMINE WHETHER THERE WERE LINKS BETWEEN CONCEPTS AND PROCEDURES, IT WAS NOTED IN THE COMMENTS.**	**T_FacY;** **T_FacN;** **T_Fac_NA**

DMT Area: What is the Teacher Physically Doing?

XIII. Teachers Type of Task (TTYP; Slide 20) What behaviors is the teacher displaying? (SII & HAREM)			**Variable Name**
	Definition	**Example**	**Variable Name**
Listening	The teacher is listening to students whose speech is directed at the teacher or the entire class which includes the teacher. During CW, at least one student (that has the spotlight) needs to be speaking to the teacher. During SW, the student with whom the teacher is interacting is speaking.		TTYPlisn
Direct instruction	The teacher is lecturing the students. **Code only during a CW or CW&SW context.** That is, in cases where the teacher is providing instruction to the whole class or to a group of students (e.g., the teacher is providing instruction, or teaching about mathematical information (e.g., the monetary system), so that students can complete (practice what they have been taught) a task. Typically,		TTYPdIns

	instruction involves new information that addresses student learning objectives. If the teacher is engaging in "private tutoring", such as when the teacher notices that a student(s) is having difficulty with a task and he or she helps the student. Also, if the teacher is responding to a question, code below.		
Posing questions	The teacher is asking students questions. Do not code if the question is part of the task that is being verbally presented. Also, note classroom organization rules for how to code verbal interactions (i.e., which students to code).		TTYPpose
Answering questions	The teacher is answering students questions. Note classroom organization rules for how to code verbal interactions (i.e., which students to code).		TTYPans
Providing a solution	The teacher is demonstrating how to solve a problem or perform a task by presenting it and demonstrating the solution. Teacher may also give the students the answer to a problem. See comments in Discourse content regarding how to code as a function of classroom organization.		TTYPsol
Giving a directive	The teacher is managing the classroom activity; **this does not include directives related to math content**. Note that usually the content of this will be coded as **Managerial Behavioral.**		TTYPdir
Copying	The teacher is copying what students are saying on the blackboard or copying information from a textbook or her notes		TTYPcopy
Verbally presenting a task	Includes re-reading the problem or clarifying parts of the problem.		TTYPverp
Providing Encouragement	This includes reinforcement or encouragement.		TTYPPenc
Checking Students' work/Observing the Classroom	The teacher is: (a) walking around surveying the students while they work in small groups or independently, and (b) correcting the students' work.		TTYPObsc
Other	The teacher is doing something that is not listed above. When the teacher is speaking but the speech that does not fit the other codes, code it here.		TTYPothr

Note: On the last slide that appears where you decide whether to continue observing or finish the observational session, select whether you have made a mistake during the coding slice. If an error occurred, record the mistake on the Corrections sheet.

DMT Area: Pedagogical Practice Rating Scale (Slide 22)

	Definition	Example	Variable Name
Pedagogical Rating Scale	At the end of the lesson, this scale is used to rate the teacher's overall pedagogical practice on a scale of 0 to 3. Note that this a scale based on observed skills, not knowledge.	0 = Only telling students information; no sharing of ideas or justifications that explain the mathematical underpinnings of various procedures 1 = teacher is more like a 0 than a 3, but not a 0 2 = teacher is more like a 3 than a 0, but not a 3 3 = Teacher integrates mathematical concepts and procedures in a meaningful manner and demonstrates knowledge of children's developing understanding of the subject	PP0; PP1; PP2; PP3

Appendix C

Video Coding Rubric

Measure 1: Focus

DMT Variable: Teacher Elicitation/Question

Teacher Elicitation: A teacher utterance intended to elicit an immediate communicative response from student(s), including both verbal and nonverbal responses. Nonverbal: Nod, shaking head.

Categories of Elicitation Codes include:
A. Content
- a. Yes/No
- b. Name/ State (information; procedure; principle/idea)
- c. Describe/Explain/Justify
- d. Compare
- e. Generate problem

B. Redirection
C. Evaluation

Note: Elicitations that apply to the Content and Evaluation categories primarily involve information directly concerned with mathematics, mathematical operations, or the lesson/task itself (e.g., supply a quantity, identify a geometric shape, explain a mathematical procedure, define a math term, evaluate a mathematical answer).

Questions to consider when analyzing the content of the teacher's statement:
1. **Does the content of the teacher's statement intend a verbal/nonverbal response?**
2. **Does the content of the teacher's statement address the subject of mathematics?**

If you answer yes to both questions, use the following codes to classify the content. If you answer no to at least one of the questions, select "not applicable" (N/A).

A. Content	Definition	Example	Variable Name
a. Yes/No	Any content elicitation that requests a simple yes or no response from student(s)	Does 4+3=7? Is this number larger than this one?	Ecy_n
b. Name/State Any content elicitation that requests a relatively short response (usually referring to labels of things). Also, an elicitation that requests a student to read a response (from a notebook, etc.) or that requests a student to choose among alternatives. Examples of statements that elicit a short response: Which group has more? How many more? So what's 4+3? What do I do to get the answer?			
b1. Name/State Information	The teacher has asked a student(s) to state information that is associated with the topic of mathematics or a mathematics task but is not considered as procedural or conceptual knowledge.	What is 78-69? Which group has more? How many apples did Sally have?	Ecn_sinf
b2. Name/State Procedure	The teacher has asked a student(s) to state knowledge of mathematical procedures (i.e., rules, properties, and principles of mathematics) associated with the topic of mathematics or a mathematics task.	What are the steps to solve 78-69?	Ecn_spro
b3. Name/State Principle/Idea	The teacher has asked a student(s) to state knowledge of mathematical concepts (i.e., ideas)	Why do 2+ 3 and 3+2 have the same	Ecn_spm

	associated with the topic of mathematics or a mathematics task.	answer?	
c. Describe/ Explain/Justify	Any elicitation that requests descriptions of a mathematical object (rather than its label), explanation of a generated solution method (rather than an answer), or a reason something is true or not true. Requesting that a student describe/explain/justify their reasoning or decision making process.	Justify solution, explain method, describe alternative method or strategy, compare quantities, describe/explain *what*, requesting a student to justify or evaluate his or her own work.	EC_D_E_J
d. Compare	An elicitation that requests the comparison of 2 or more strategies or procedures already completed	Can you tell me the difference between what you did and what Sam did?	ECcomp
e. Generate a problem	Students are asked to generate (come up with) their own stories or problems to illustrate math ideas, concepts, principles, operations	Generate a story to match a number sentence. Generate a problem to fit given constraints. Generate a number sentence to fit a word problem.	ECgenprb
B. Redirection	An elicitation that requests a student to modify his/her behavior, to acknowledge his/her participation in some current activity, to recall specific classroom procedures or rules, or to gain students' attention. This category does NOT involve mathematical content. Rather, the student's behavior is redirected to the task at hand. The redirection of the students' behavior requires a *communicative (verbal or nonverbal)* response from the student.	Are you listening? Tell me what Johnny just said? What are you supposed to be doing?	Eredir
C. Evaluation	An elicitation that requests a student(s) to evaluate another student's answer, response, strategy, etc. Not only involves evaluating the accuracy of an answer, but can also involve evaluating another student's solution strategy. Listen for words such as: best, better, coolest, smartest, neatest. This differs from Compare in that the student is not elicited to compare more than one solution or strategy, but rather involves a student being asked to make a judgment of another student's solution and/or strategy. Teacher's request to evaluate another student's answer can also involve judging whether the answer is correct or incorrect (e.g., thumbs up if the answer is correct or thumbs down if the answer is incorrect)	Which strategy did you like best, why? Does that strategy work?	EEval

Other	An elicitation that does not fit into any of the above categories, including all forms of conversational repair. When an elicitation occurs in the middle of a student's long response, it may be coded as Other when it is obvious that the teacher does not intend to terminate the response but to clarify a part of response.	Did you bring your book with you today?	EOther
N/A	The content of the statement was not an elicitation and/or it was not related to the topic, teaching or learning of mathematics.		E_NA

Measure 2: Method (part I)

DMT variable: Direct Instruction

Direct Instruction: A teacher utterance intended to provide information to the student(s); does not require communicative or physical response from students. The teacher did not elicit a response from the students and the statement content was mathematical in nature.

Categories of Direct Instruction Codes include:
A. Name/State (information, procedure, and principle)
B. Describe/Explain/Justify
C. Compare
D. Expert Modeling

Note: Direct instruction involves information directly concerned with mathematics, mathematical operations, or the lesson itself. Supply a quantity, identify a geometric shape, explain a mathematical procedure, define a math term, evaluate a mathematical answer.

Questions to consider when analyzing the content of the teacher's statement:

1. **Does the content of the teacher's statement intend a verbal/nonverbal response?**
2. **Does the content of the teacher's statement address the subject of mathematics?**

If you answer no to question 1 and yes to question 2, use the following codes to classify the content. If you answer no to both questions, select "not applicable" (N/A).

A. Name/State	**Definition**	**Example**	**Variable Name**
A. Name/State Information	The teacher describes features of a subject/problem.	The goal of problem solving	Din_sinf
A. Name/State Procedure	The teacher states a procedure (i.e., rules, properties and principles of mathematics) to help the students understand a topic/problem. No explanation of why is provided – when an explanation is given, code as D/E/J.	To divide a whole number by a fraction, you inverse the fraction (the divisor) and multiply the whole number by the reciprocal.	Din_spro
A. Name/State Principle/Idea	The teacher states a concept to help the students understand a math topic/problem. No explanation of why is provided – when an explanation is, given code as D/E/J.	The concept of place value explains why certain partial products are powers	Din_spm

		of 10.	
B. Describe/ Explain/Justify	The teacher provides information and explains/justifies notions addressed in the information stated.	The distributive property explains why you multiply a number to all digits in a number in accordance with their place value.	DI_D_E_J
C. Compare	The teacher compares responses or information stated by students or from some other referent (e.g., textbook). If the teacher is making a comparison to support a D/E/J, code both.	To answer 3 + □ = 8, Jim counted how many cubes he added to 3 to get to 8. Tammy, on the other hand, subtracted 3 from 8 in her head.	DI_com
D. Expert Modeling	The teacher is verbally modeling a concept or procedure in accordance with how she or he conceptualizes it. The teacher may pose a question that is intended for her/himself to answer. Code during CW organization when teacher provides the solution.	So first I add the values in the ones place right, and then…	DIExpMod
N/A	The teacher is not providing any direct instruction.		DI_NA

<u>Measure 2: Method (part II)</u>

DMT Variable: Context of Teacher Task Presentation

Type of Task Regarding Teacher Presentation: What *contextual features* is the teacher *using to present* or demonstrate a task, concept, procedure, or problem

Coding Rules:
This section is to be coded when the teacher is actually presenting a task. Some tasks require the teacher to present several problems that fall under the same type of task; code this each time the problem changes (e.g., show me 100; show me 99).

When the teacher is simply re-stating the entire problem or parts of the problem (i.e., to clarify), code N/A and code behavior as verbally presenting the task if applicable.

Variable	**Definition**	**Example**	**Variable Name**
Words	**Words:** Teacher is using words, written or spoken, to present the task.	Writing on the blackboard; describing a feature of the task; reading a problem	PRESwrds
Mathematical Notations	**Numbers or symbols**: Mark this category if the teacher is using numbers and/or symbols to present something to the students. Includes worksheets, flashcards, and other purely symbolic means by	The teacher uses the numeral 5 to represent the idea of five objects.	PRESnota

	which students might learn about representations, facts, or procedures. If the worksheet or flashcard includes only pictures or diagrams, however, record this as Pictures. When geometric shapes are used to represent geometric concepts, choose this code. If, however, geometric shapes are used simply as pictures or counting objects, code as Pictures.	The teacher demonstrates adding with fractions using only numbers and symbols.	
Physical Materials	**Concrete materials**: Mark this category if the teacher presents materials (e.g., pattern blocks, fraction pieces, bean sticks, fingers) to work on the task and if those materials are not intended to be used in a game format (for materials used for the purpose of a game, code as Math Games).	The teacher counts concrete objects or shows how fractions are equivalent using pattern blocks or diagrams to represent same-sized but differently named areas.	PRESphys
Story/word problems	Mark this category if the teacher is creating a fictional story to present a math concept or demonstrate its solution using contextualized situations. This category also includes both situations developed from classroom life and word problems found in curriculum materials or written by the teacher or students.	Story problems about needing to find change at the school store, comparing the height of two third-graders, or doubling fractional teaspoons in a recipe.	PRESstry
Tables/Charts	**Tables or charts**: Mark this category if the teacher presents a task using tallies, tables, or charts to work in the focal topic category. The teacher might have constructed tables or charts, or they might have been available in curriculum materials or other mathematics materials.	Table of students' favorite fruits	PREStble
Math Games	Teacher is using game materials to present a task	Bingo cards; other manipulatives intended for use in a game situation	PRESgame
Pictures	**Pictures or diagrams**: Mark this category if the teacher is using pictures or diagrams to work in the focal topic category. The teacher might have constructed pictures or diagrams, or they might have been available in curriculum materials or other mathematics materials. If the teacher worked with number lines or graphs, record that here. If the diagram was a table or a chart, however, mark in Tables/Charts instead.		PRESpix
Other	The teacher used something other than what has been listed to demonstrate or present a task to the students		PRESothr
N/A	The teacher did not present or demonstrate a task or problem to the students	PRES_NA	

Measure 3: Classroom Organization

DMT Variable: Classroom Organization

Defining Class Work (CW) Class Work: the teacher is working with all or most of the students in a whole-class situation; the type of talk is predominantly public, that is, the audience is the whole class. For example: Teacher is lecturing or demonstrating to the entire group (or most); student explaining a strategy to the entire group (or most).			
Class Work	**Definition**	**Example**	**Variable Name**
CW T	Class Work Teacher: within a *whole-class situation*, the present activity involves the teacher as the primary speaker	Setting-up physically or giving directions in preparation for the upcoming lesson	CW1
CW Ss and T	Class Work Students and Teacher: within a *whole-class situation*, the present activity involves both student and teacher leading the class together	Working on tasks, sharing solutions, correcting homework, etc.	CW2

Defining Seat Work Students (SWS) Seat Work Students: a period of time during the lesson when students work independently on assigned tasks, either alone or in small groups. The type of talk is predominantly private, although there may be instances of public talk as well (as when the teacher makes an announcement to the whole class). Example: The beginning of seat work is usually marked by a) a teacher announcement that students should begin their work; b) a period of silence after the teacher provides necessary information to students; and c) students actually start working.			
Seat Work	**Definition**	**Example**	**Variable Name**
SW Individual	Seat Work Individual: Students are engaged in independent and individual work on assigned tasks (independent of the teacher, and individually)	Students work alone at their own desks with little *math-related* interaction taking place.	SWSs3
SW Small Groups	Seat Work Small Groups: Students work independently in small groups (2 or more) on assigned tasks (independent of the teacher)	Students work in groups of two or more, and interact *mathematically* around content.	SWSs4
SW Both	Seat Work Both: Students work independently (of the teacher) on assigned tasks, some individually and others in small groups.	Any organizational combination of the above two types	SWSs5
CW/SW	Class Work/Seat Work Combination: Some students work independently on assigned tasks while the rest of the class works with the teacher.	Most students watch the teacher demonstrating while a few work independently to complete other work.	CW_SW

Defining Seat Work Teacher Seat Work Teacher: What is the teacher doing while students work independently on tasks?			
	Definition	**Example**	**Variable Name**
SW T Interaction	Seat Work Teacher Interaction: The teacher interacts with students as they work on assigned tasks.	Teacher Interacts with individuals or small groups of students: circulating around the room, checking progress, posing/answering questions, etc.	SWT7
SW T No Interaction	Seat Work Teacher No Interaction: The teacher does not interact with students as they work on assigned tasks.	Teacher remains seated at his/her desk, is busy with other non-math related tasks	SWT8

Table 1

Theoretical criteria for levels of variable frequencies (f) by instructional profile

Measure	DMT Category	DMT Variable	Procedural *f*	Reform *f*
Focus	Teacher Elicitations	Yes/No	High	Low
		Name/State Information	High	Low
		Name/State Procedure	High	Low
		Name/State Principle	High	Low
		Describe/Explain/Justify	Low	High
		Compare	Low	High
		Generate Problem	Low	High
		Evaluate	Low	High
Methods	Direct Instruction	Name/State Information	High	Low
		Name/State Procedure	High	Low
		Name/State Principle	High	Low
		Describe/Explain/Justify	Low	High
		Compare	Low	High
		Expert Modeling	Low	High
	Context of Teacher's Task Presentation	Notations	High	Low
		Physical materials	Low	High
		Story problems	Low	High
		Tables	Low	High
		Games	Low	High
		Pictures	Low	High
Classroom Organization	Classroom Organization			
	Class work	CW Teacher	High	Low
		CW Teacher & Students	Low	High
		CW/SW Combination	Low	High
	Seat work	SW Individual	High	Low
		SW Small Groups	Low	High
		SW Both	Low	High
		Teacher Interaction	Low	High
		Teacher No Interaction	High	Low

Table 2

Frequency (f) and percentage frequencies (%) of distributions of variables for DMT and video coding of total slices across all five lesson

		DMT		Video	
Category	Variable	*f*	%	*f*	%
Teacher Elicitations	Yes/No	14	4.13	88	28.95
	Name/State Information	51	15.04	232	76.32
	Name/State Procedure	7	2.06	14	4.61
	Name/State Principle	1	0.29	0	0.00
	Describe/Explain/Justify	17	5.01	68	22.37
	Compare	0	0.00	0	0.00
	Generate Problem	0	0.00	0	0.00
	Redirection	3	0.88	5	1.64
	Evaluate	2	0.59	7	2.30
	Other	23	6.78	100	32.89
	Not Applicable	230	67.85	70	23.03
Direct Instruction	Name/State Information	21	6.19	57	18.75
	Name/State Procedure	2	0.59	2	0.66
	Principle	2	0.59	1	0.33
	Describe/Explain/Justify	3	0.88	24	7.89
	Compare	0	0.00	0	0.00
	Expert Modeling	11	3.24	22	7.24
	Not Applicable	300	88.50	227	74.67
Context of Teacher's Task Presentation	Words	52	15.34	47	15.46
	Notations	28	8.26	29	9.54
	Physical materials	24	7.08	23	7.57
	Story problems	45	13.27	40	13.16
	Tables	0	0.00	0	0.00
	Games	0	0.00	0	0.00
	Pictures	14	4.13	15	4.93
	Other	0	0.00	0	0.00
	Not Applicable	286	84.37	258	84.87
Classroom Organization	Class Work Teacher	11	3.24	14	4.61
	Class Work Teacher and Students	108	31.86	104	34.21
	Class Work/Seat Work Combination	2	0.59	0	0.00
	Seat Work Individual	111	32.74	95	31.25
	Seat Work Small Groups	107	31.56	91	29.93
	Seat Work Both	0	0.00	0	0.00
	Teacher Interaction	216	63.72	185	60.86
	Teacher No Interaction	2	0.59	1	0.33

Note. The percent frequencies were calculated by dividing the frequencies by the total number of slices across all five lessons (339 for DMT; 304 for video).

Table 3

Frequency (f) and percentage frequencies (%) of distributions of variables for DMT and video coding of applicable slices across all five lessons

Measure	DMT Category	DMT Variable	DMT *f*	DMT %[a]	Video *f*	Video %[b]
Focus	Teacher Elicitations	Yes/No	14	12.84	88	37.61
		Name/State Information	51	46.79	232	99.15
		Name/State Procedure	7	6.42	14	5.98
		Name/State Principle	1	0.92	0	0.00
		Describe/Explain/Justify	16	15.60	68	29.06
		Compare	0	0.00	0	0.00
		Generate Problem	0	0.00	0	0.00
		Redirection	3	2.75	5	2.14
		Evaluate	2	1.83	7	2.99
		Other	23	21.10	100	42.74
Methods	Direct Instruction	Name/State Information	21	53.85	57	74.03
		Name/State Procedure	2	5.13	2	2.60
		Name/State Principle	2	5.13	1	1.30
		Describe/Explain/Justify	3	7.69	24	31.17
		Compare	0	0.00	0	0.00
		Expert Modeling	11	28.21	22	28.57
	Context of Teacher's Task Presentation	Words	52	98.11	47	102.17
		Notations	28	52.83	29	63.04
		Physical materials	24	45.28	23	50.00
		Story problems	45	84.91	40	86.96
		Tables	0	0.00	0	0.00
		Games	0	0.00	0	0.00
		Pictures	14	26.42	15	32.61
		Other	0	0.00	0	0.00
Classroom Organization	Classroom Organization					
	Class work	CW Teacher	11	9.09	14	11.86
		CW Teacher & Students	108	89.26	104	88.14
		CW/SW Combination	2	1.65	0	0.00
	Seat work	SW Individual	111	50.92	95	51.08
		SW Small Groups	107	49.08	91	48.92
		SW Both	0	0.00	0	0.00
		Teacher Interaction	216	99.08	184	99.46
		Teacher No Interaction	2	0.92	1	0.54

[a] The DMT percent frequencies were calculated by dividing the frequencies by the number of applicable slices (i.e., slices not coded at "not applicable") for each DMT category, as follows: 109 slices for Teacher Elicitations, 39 for Direct Instruction, and 53

for Context of Teacher's Task Presentation. For Classroom Organization, the number of applicable slices was distinguished by type, as follows: 121 slices for class work (CW teacher, CW teacher and students, CW/SW combination), and 218 for seat work (SW individual, SW small groups, SW both) and interaction (teacher interaction, teacher no interaction).

[b] The video percent frequencies were calculated by dividing the frequencies by the number of applicable slices, as follows: 234 for Teacher Elicitations, 77 for Direct Instruction, 46 for Context of Teacher's Task Presentation, and for Classroom Organization, 118 for class work, and 186 for seat work and interaction.

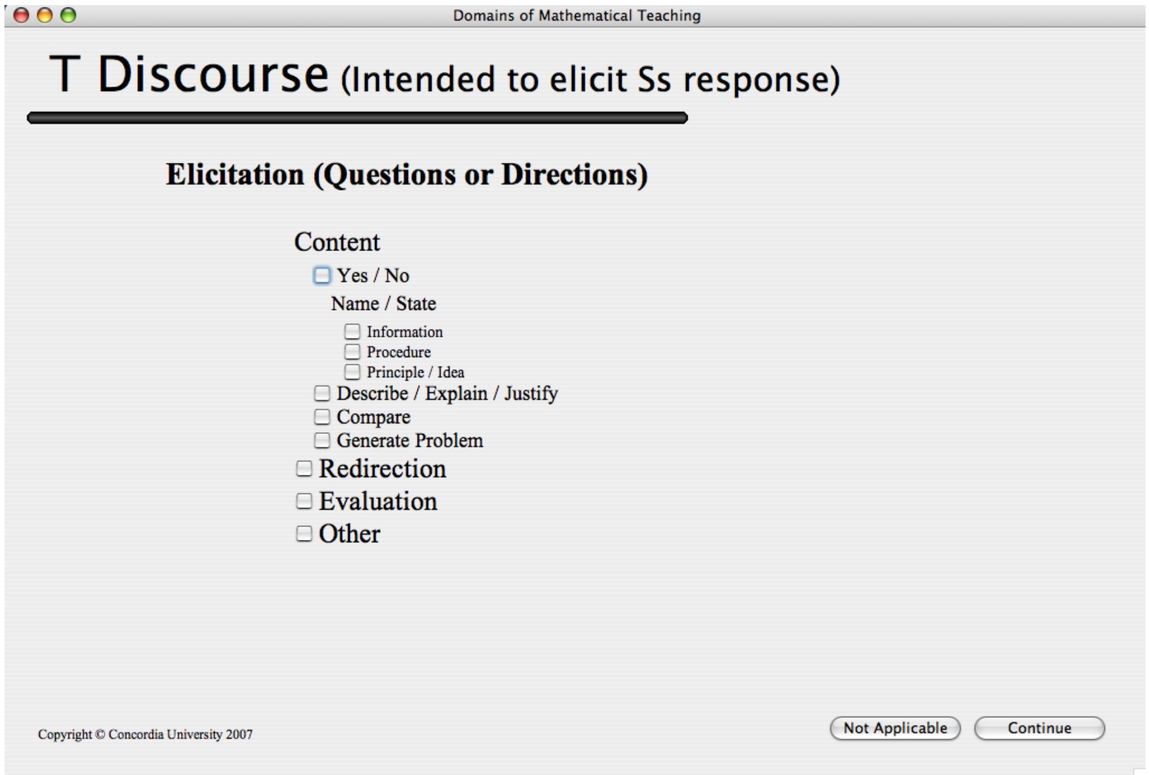
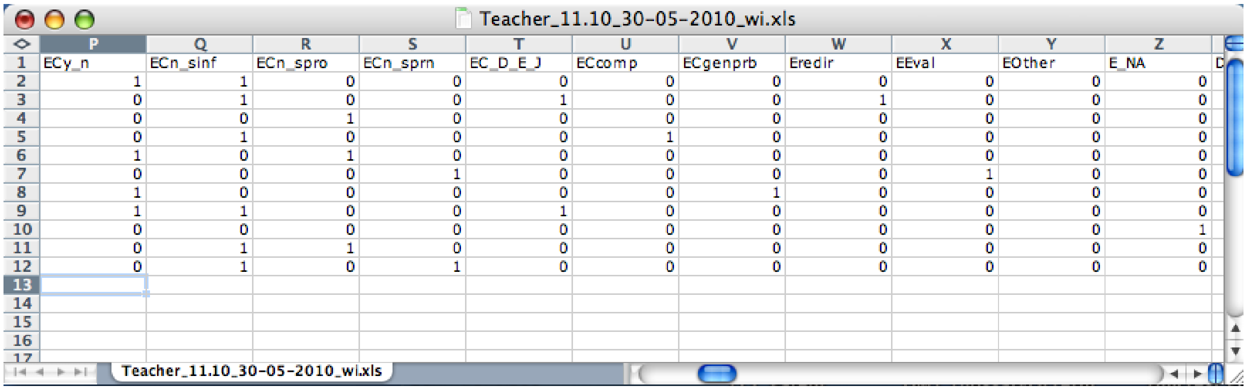


Figure 1. Illustration of a DMT screen displaying the check box options for Teacher Discourse: Elicitation.



Teacher_11.10_30-05-2010_wi.xls

	P	Q	R	S	T	U	V	W	X	Y	Z
1	ECy_n	ECn_sinf	ECn_spro	ECn_sprn	EC_D_E_J	ECcomp	ECgenprb	Eredir	EEval	EOther	E_NA
2	1	1	0	0	0	0	0	0	0	0	0
3	0	1	0	0	1	0	0	1	0	0	0
4	0	0	1	0	0	0	0	0	0	0	0
5	0	1	0	0	0	1	0	0	0	0	0
6	1	0	1	0	0	0	0	0	0	0	0
7	0	0	0	1	0	0	0	0	1	0	0
8	1	0	0	0	0	0	1	0	0	0	0
9	1	1	0	0	1	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	1
11	0	1	1	0	0	0	0	0	0	0	0
12	0	1	0	1	0	0	0	0	0	0	0

Teacher_11.10_30-05-2010_wi.xls

Figure 2. Illustration of a sample Microsoft Excel spreadsheet with the Teacher Discourse: Elicitation codes.

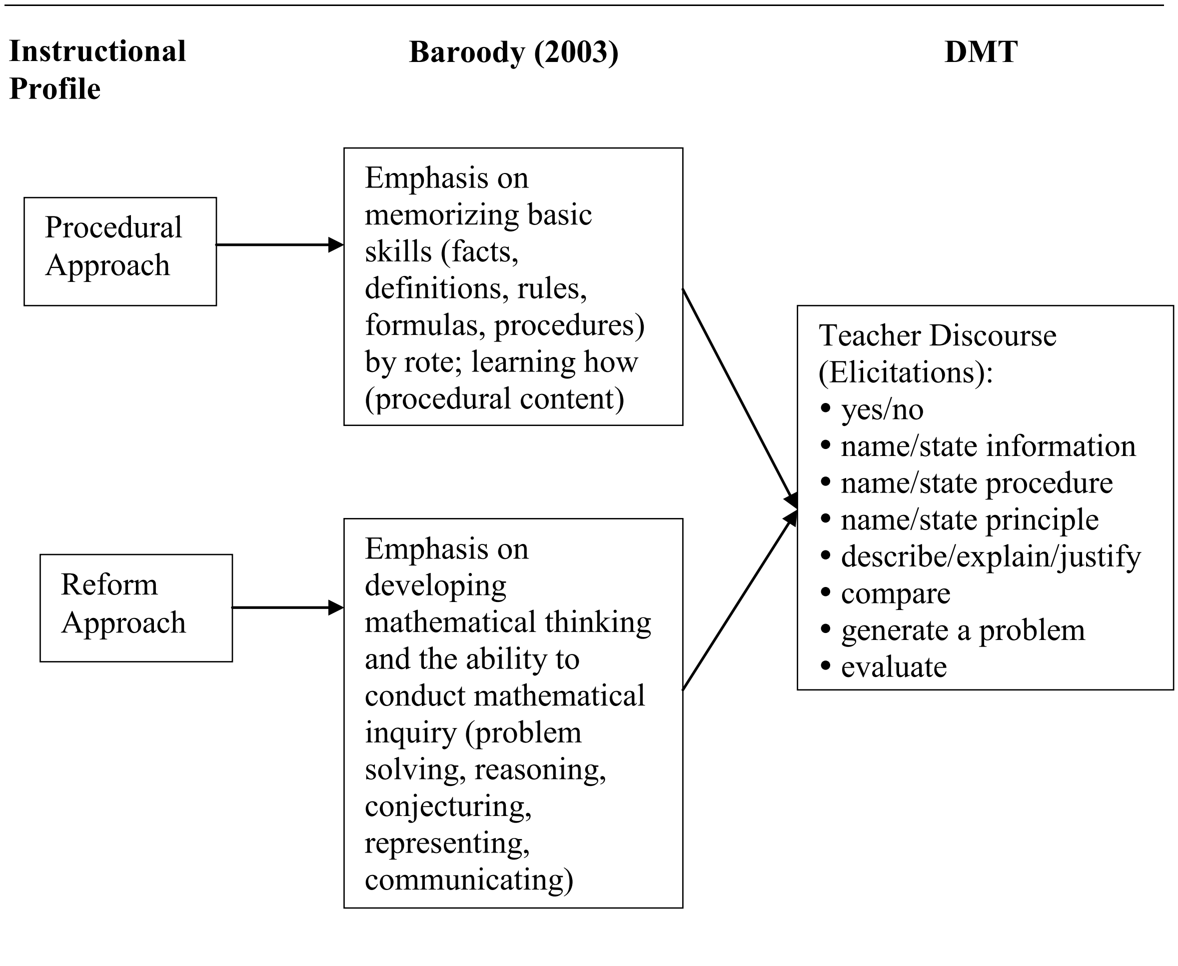


Figure 3. Correspondence between the Focus measure of the procedural and reform profiles and DMT variables.

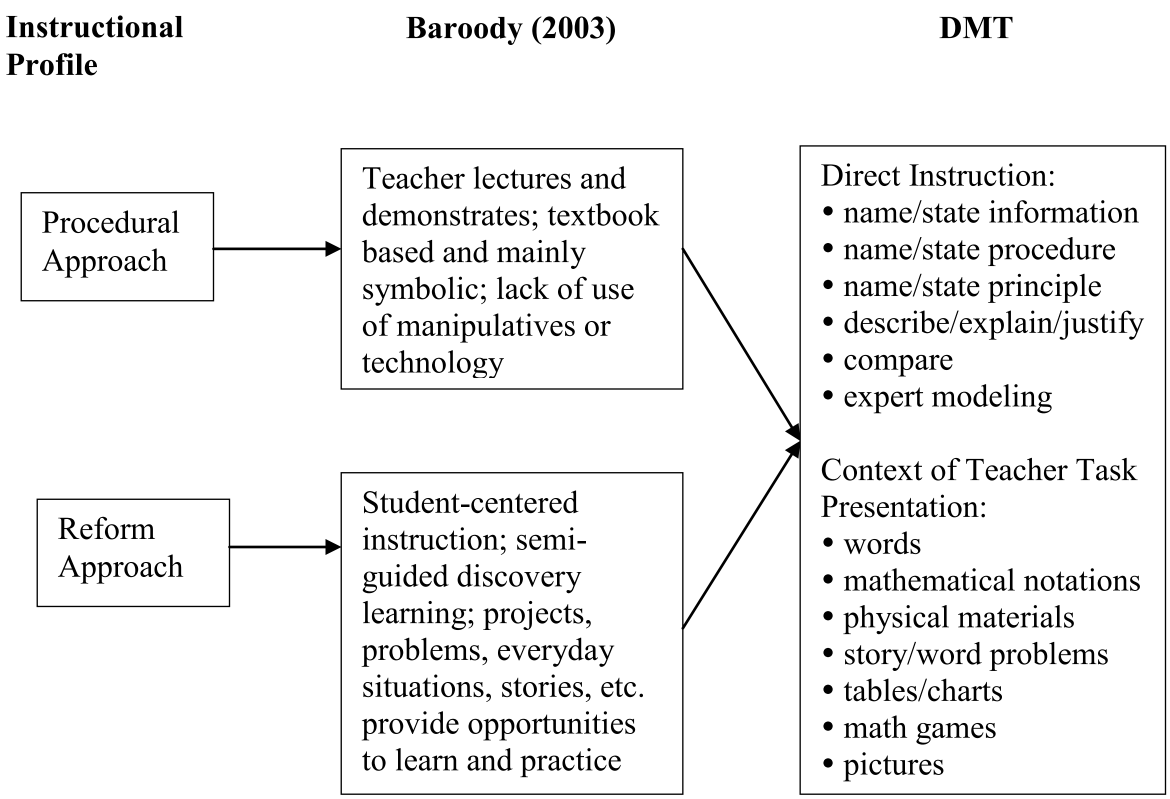


Figure 4. Correspondence between the Methods measure of the procedural and reform profiles and DMT variables.

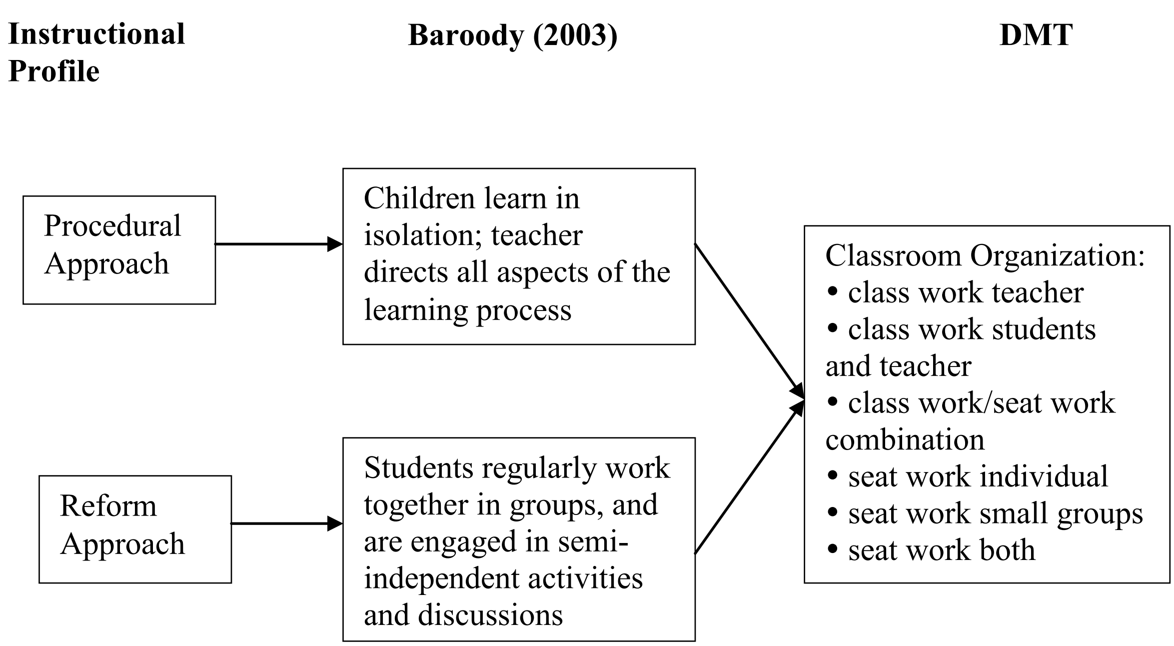


Figure 5. Correspondence between the Classroom Organization measure of the procedural and reform profiles and DMT variables.

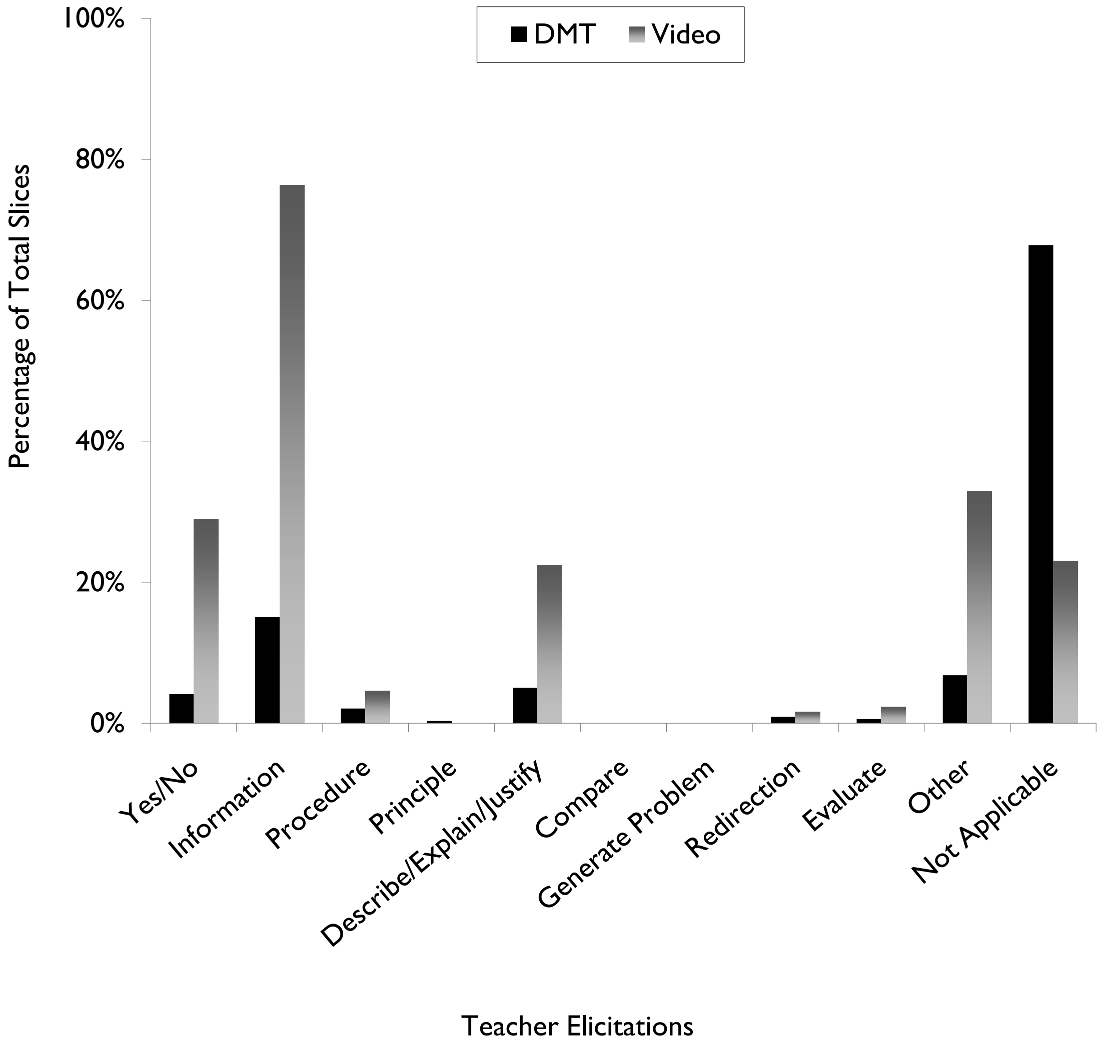


Figure 6. Comparison of the percentage of total slices for the DMT and video's Teacher Elicitations variables.

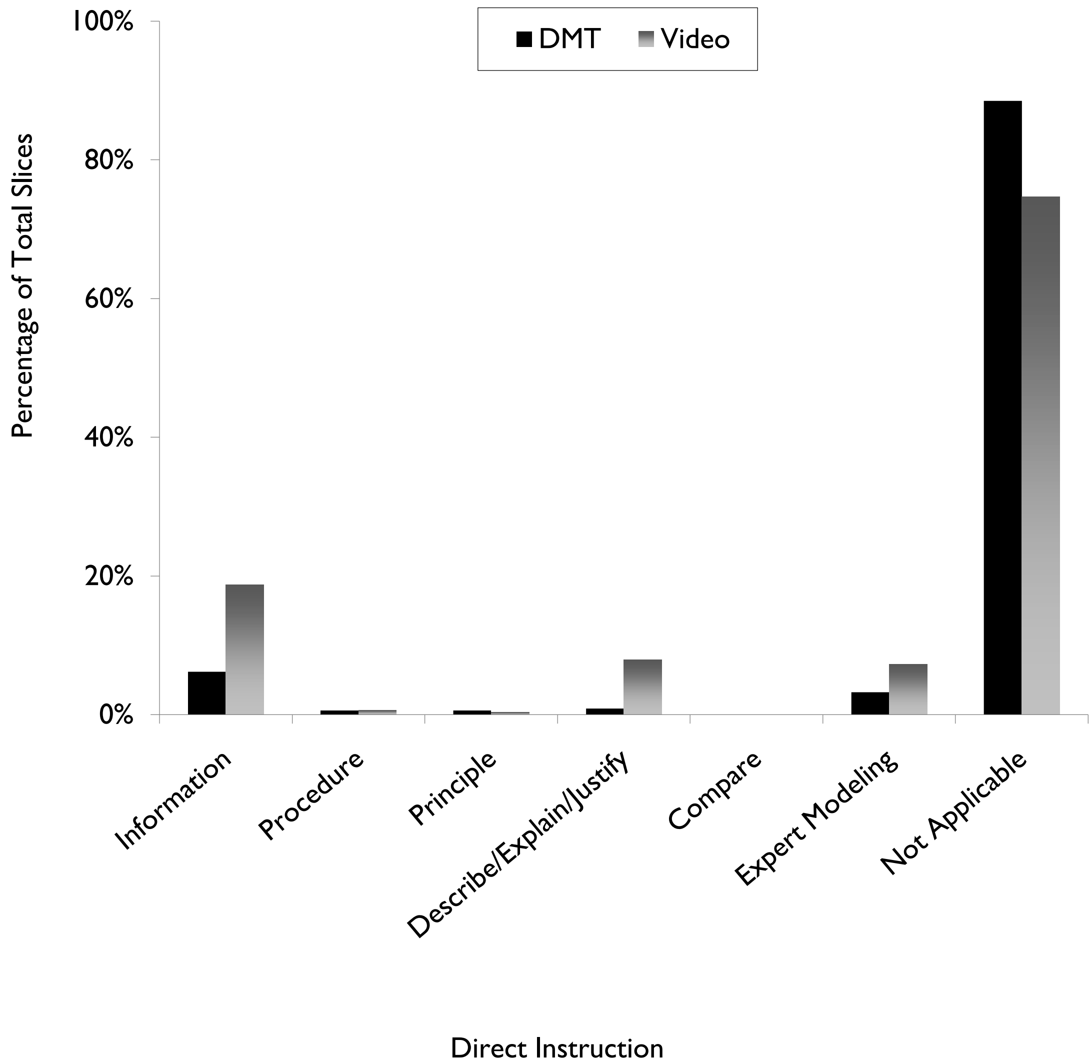


Figure 7. Comparison of the percentage of total slices for the DMT and video's Direct Instruction variables.

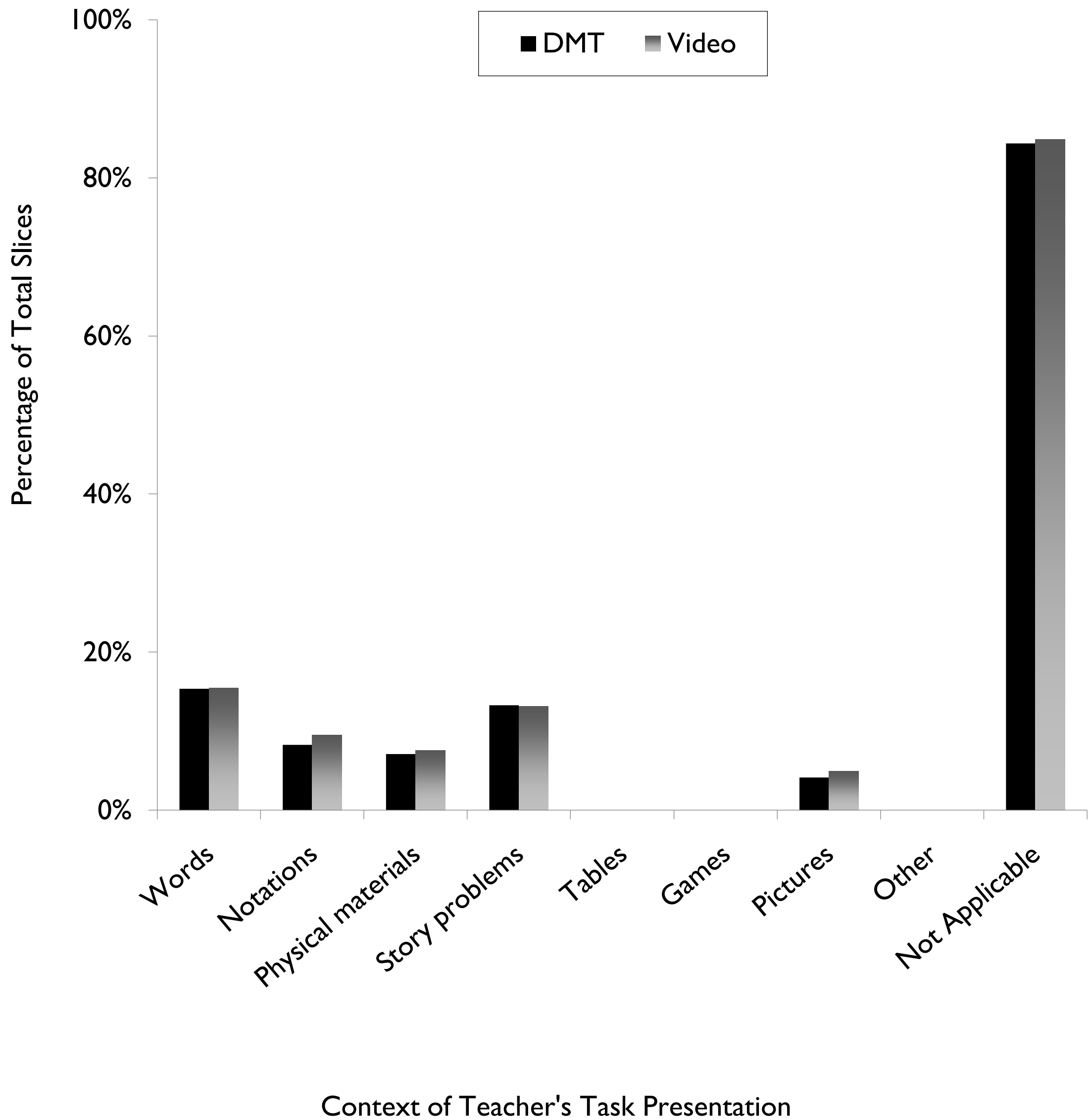


Figure 8. Comparison of the percentage of total slices for the DMT and video's Context of Teacher's Task Presentation variables.

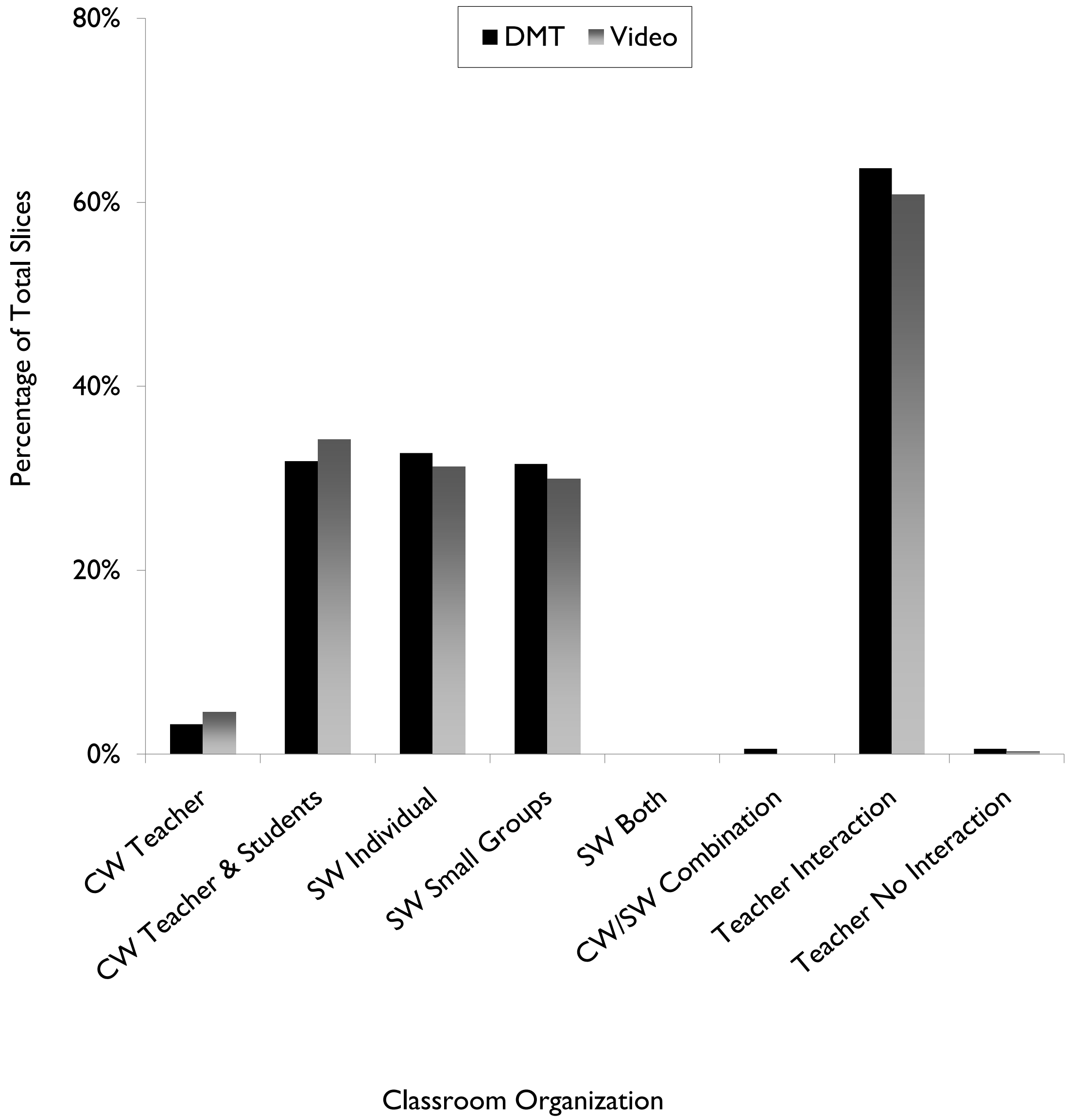


Figure 9. Comparison of the percentage of total slices for the DMT and video's Classroom Organization variables.

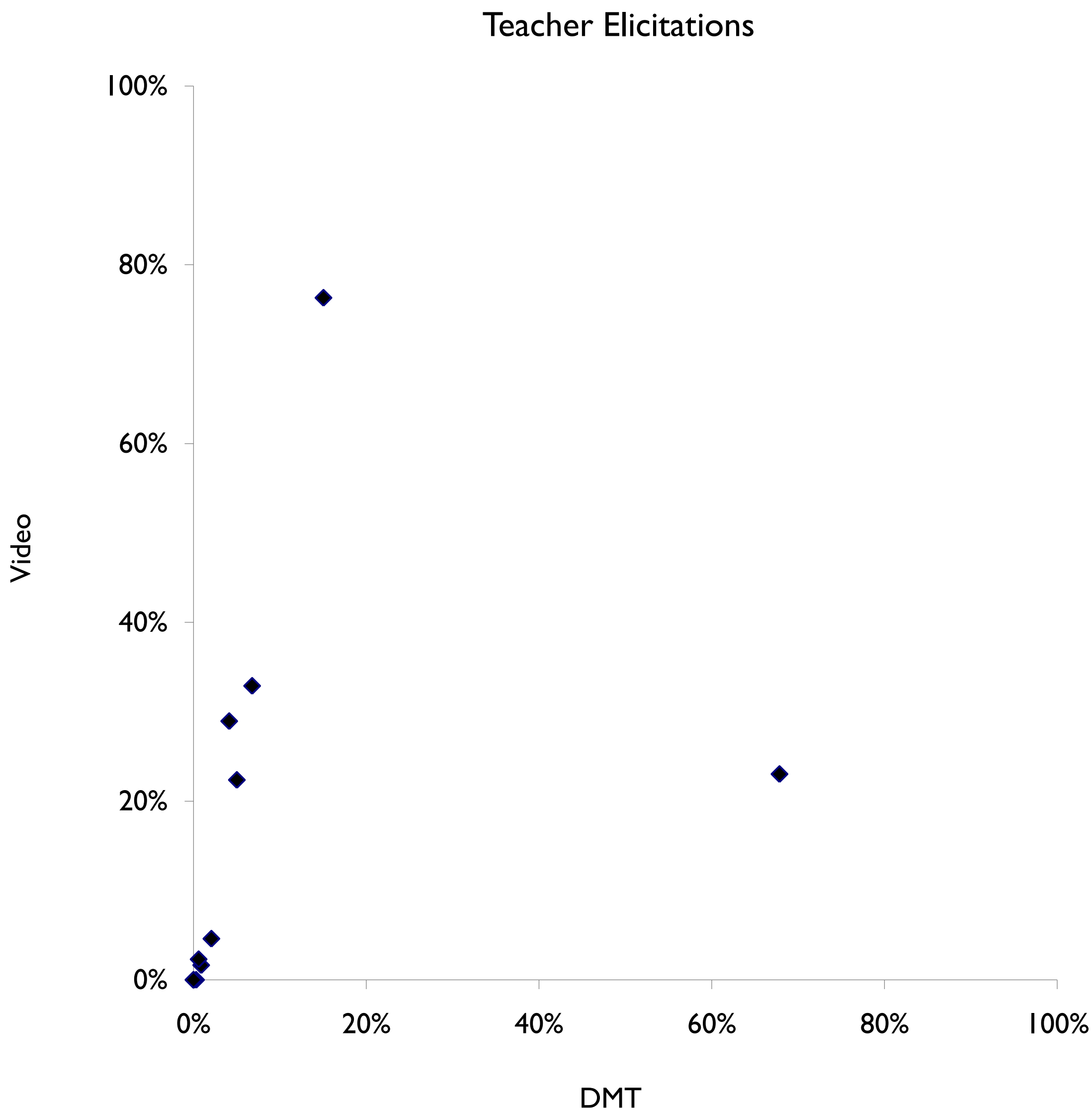


Figure 10. Relationship between the DMT and video data's frequency percentages for the Teacher Elicitations variables.

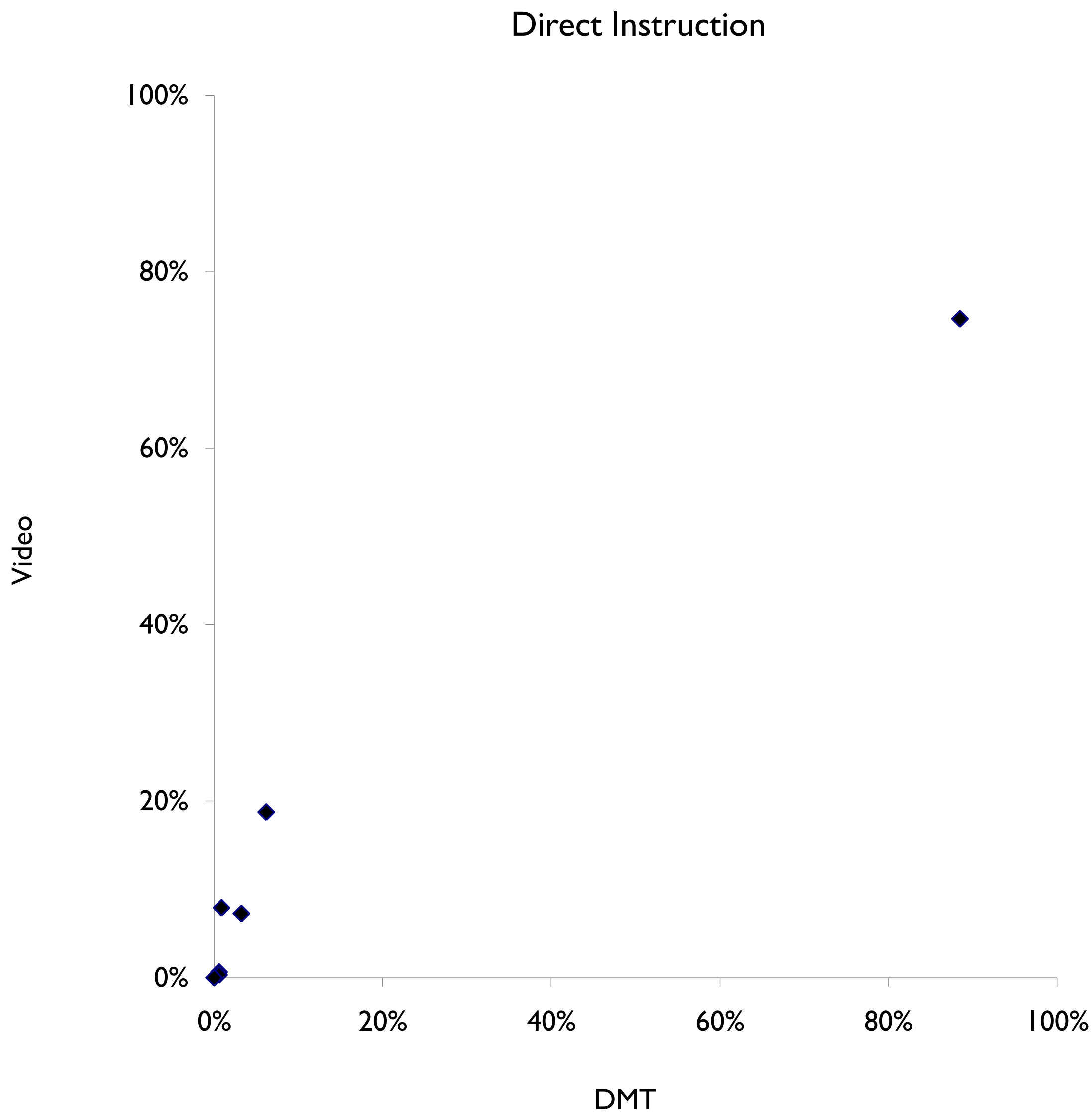


Figure 11. Relationship between the DMT and video data's frequency percentages for the Direct Instruction variables.

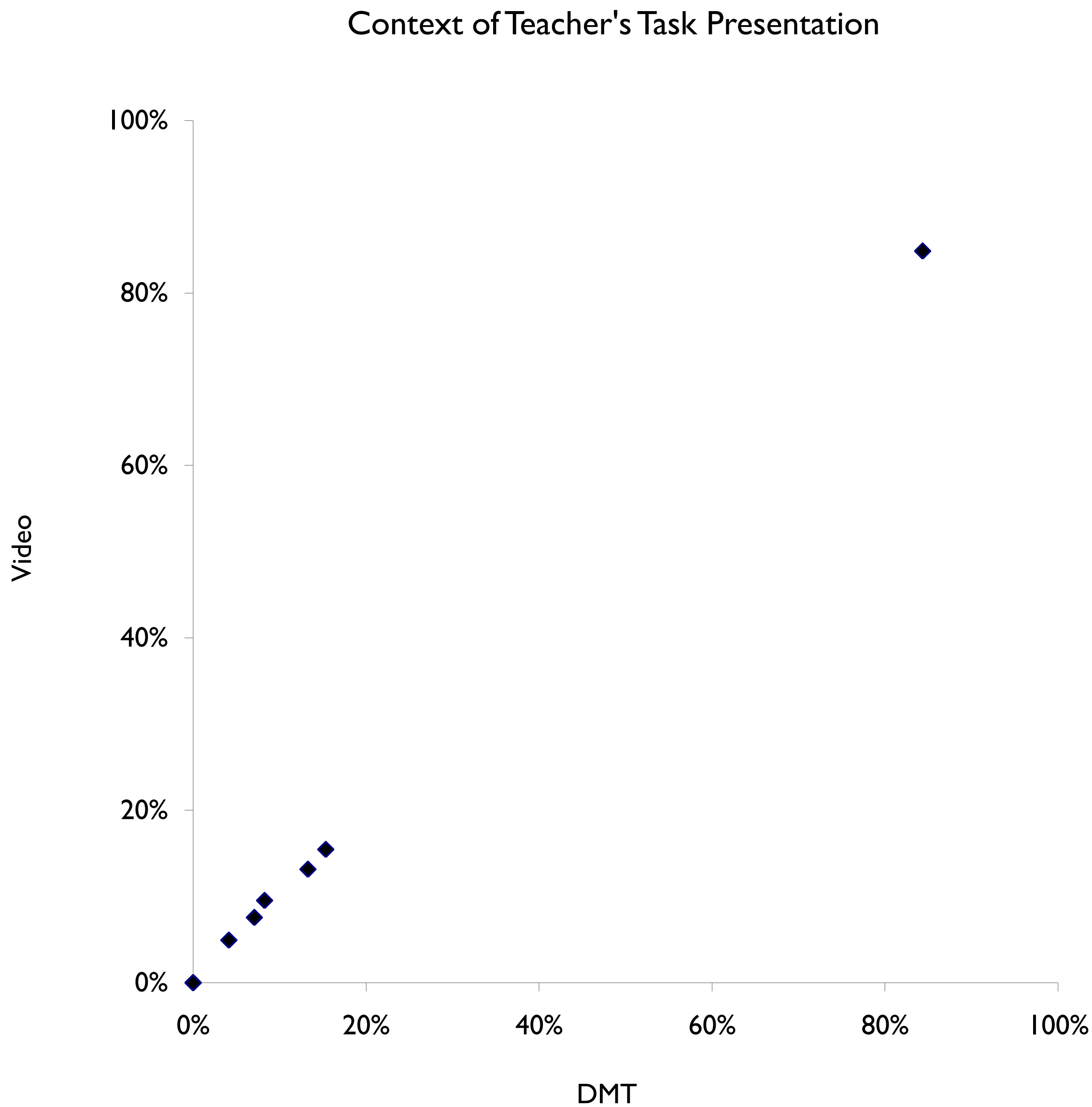


Figure 12. Relationship between the DMT and video data's frequency percentages for the Context of Teacher's Task Presentation variables.

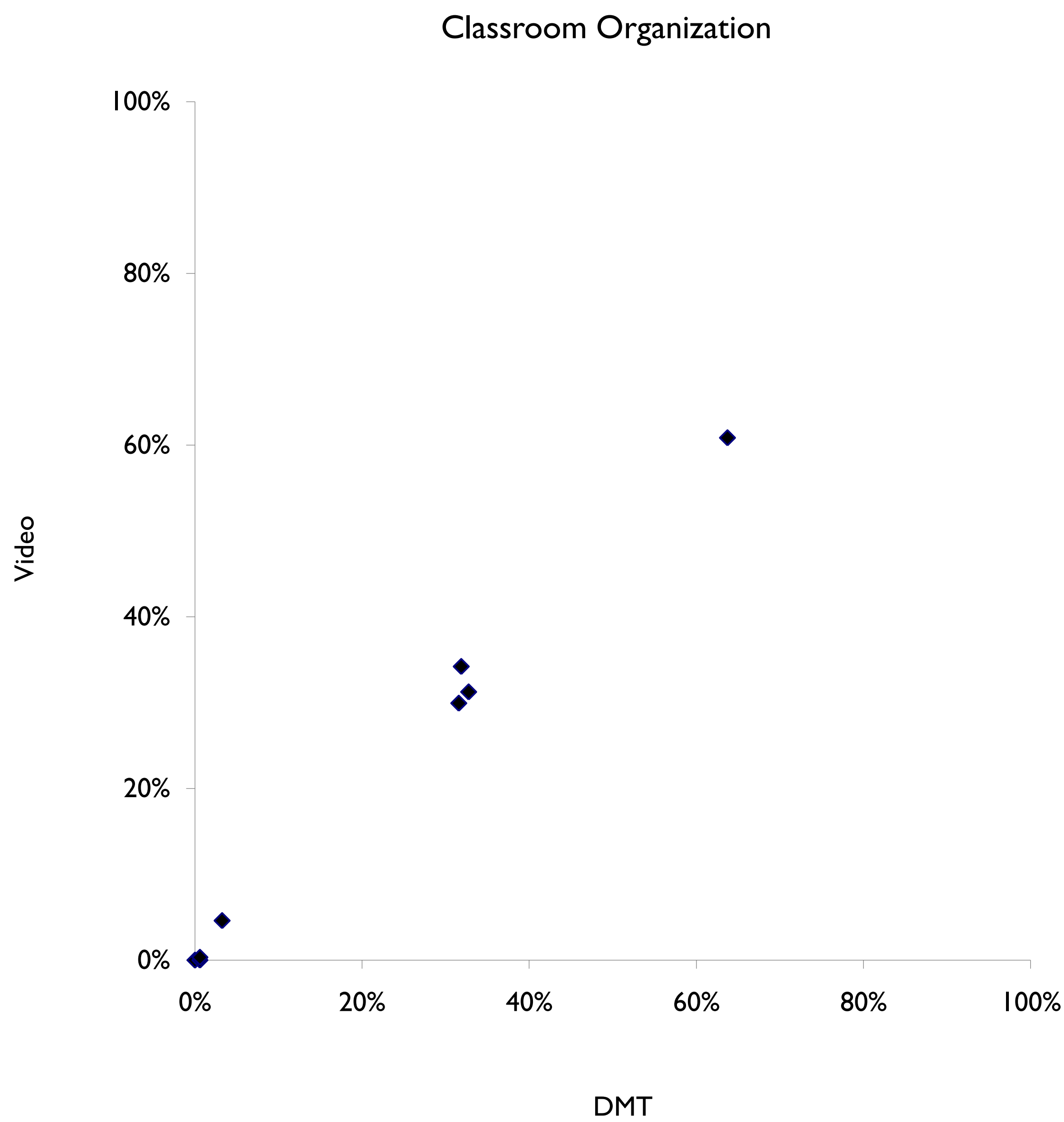


Figure 13. Relationship between the DMT and video data's frequency percentages for the Classroom Organization variables.

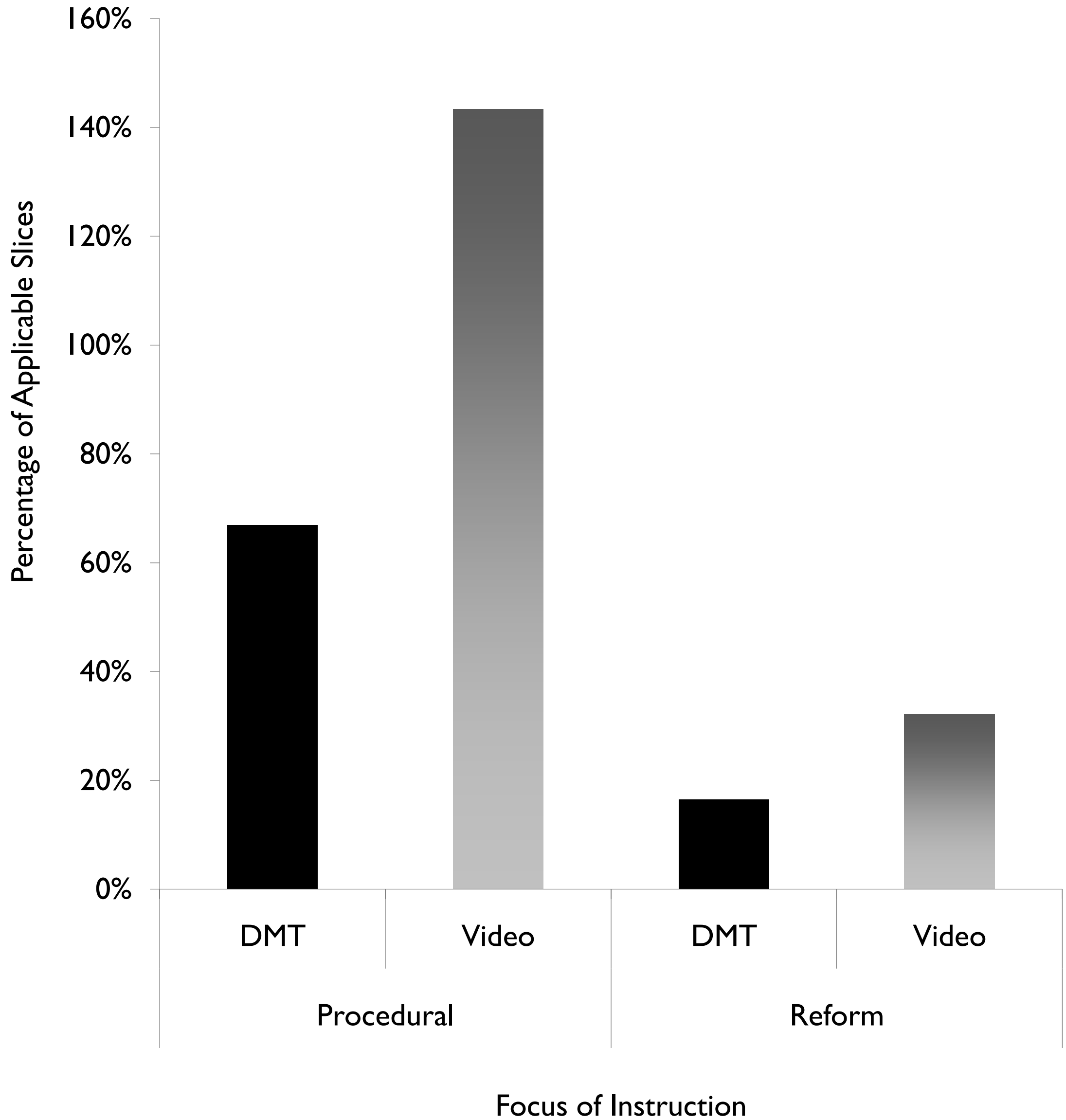


Figure 14. Comparison of the DMT and video frequencies of procedural- and reform-oriented focus of instruction.

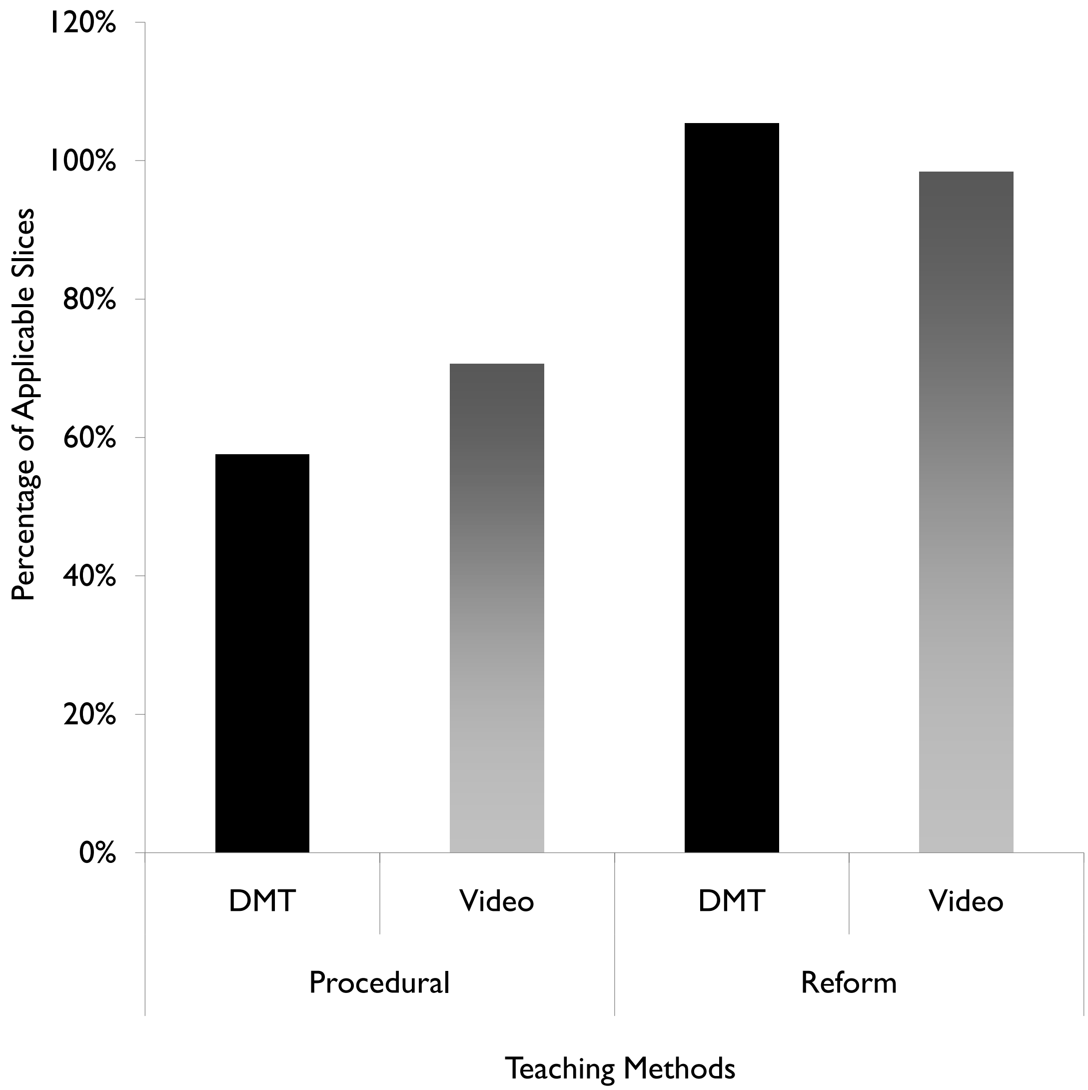


Figure 15. Comparison of the DMT and video frequencies of procedural- and reform-oriented teaching methods.

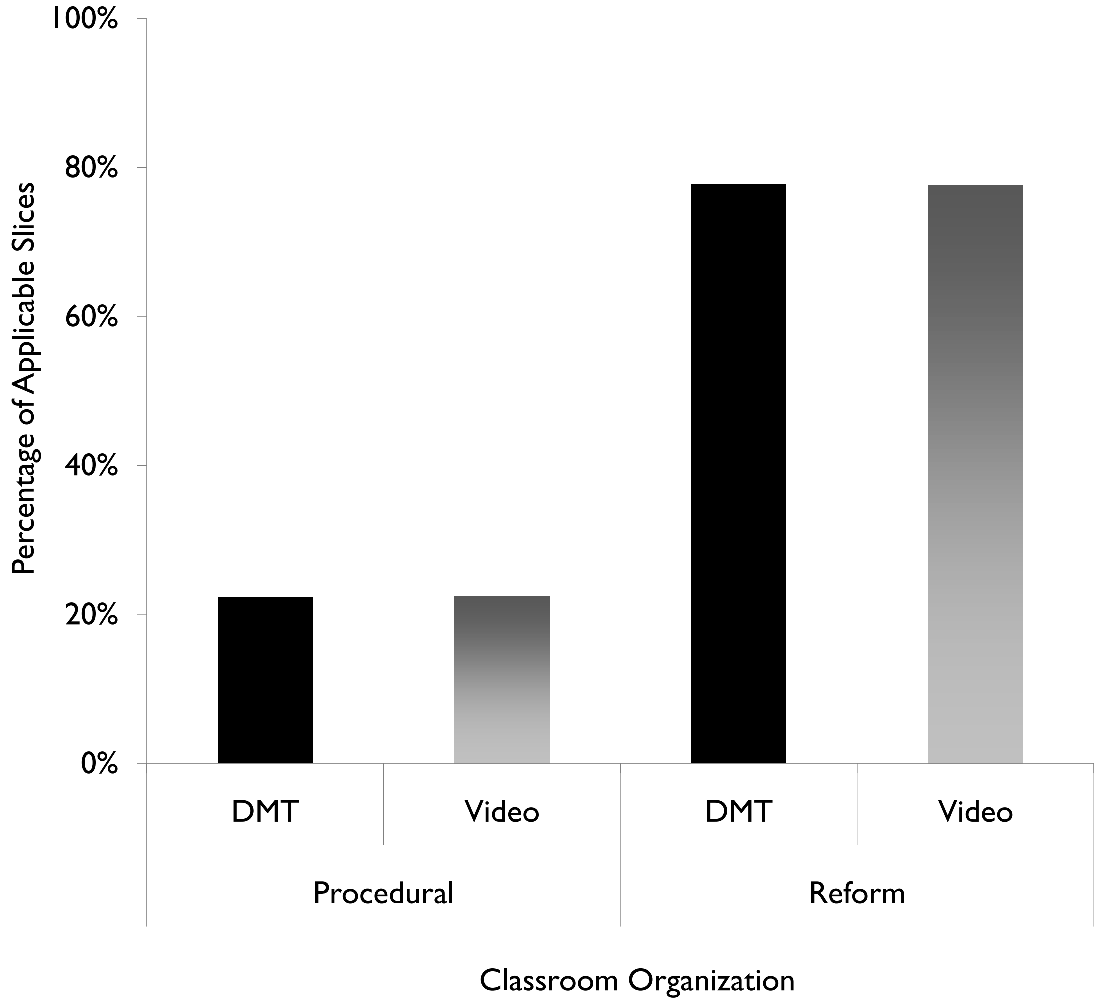


Figure 16. Comparison of the DMT and video frequencies of procedural- and reform-oriented classroom organization.