DOCUMENTING SYSTEMIC REFORM IN MATHEMATICS: A CASE STUDY OF ONE MIDDLE SCHOOL

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A Dissertation Submitted to the
Faculty of Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
in
Curriculum and Instruction

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June 24, 2003
Blacksburg, Virginia

Keywords: Systemic Reform, Lead Teachers, Longitudinal Case Study. Middle School Mathematics, Qualitative Research, Constructivist Mathematics

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Abstract

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An operational definition of Systemic Reform is used to document a case study of mathematics education reforms occurring in the mathematics classrooms of one middle school in one school division in one state. The middle school had two lead teachers who participated in the training component of a National Science Foundation-funded state-wide Systemic Reform Initiative.

Systemic Reform conceptualized reform as combining bottom-up reform with top-down support. Therefore, the research methodology confronted the challenges of the breadth and complexity of Systemic Reform through the use of selective data in the form of artifacts, interviews, and observations from four populations: (1) classroom teachers, (2) building administrators, (3) district administrators, and (4) state-level staff.

The study was conducted at four levels over a five-year period to provide the focus for longitudinal data collection to document: (1) the status of mathematics education during the 1995-96 primary data collection year, (2) the evolution of mathematics education reform over the course of the five year period, and (3) the manner in which Systemic Reform occurred.

All levels of educators involved made an initial five-year commitment as active participants in the State's Systemic Reform Initiative, but only the Lead Teacher actually carried through with this commitment. After the first year division-level administrators shifted the focus of reform efforts to the elementary schools and discontinued support for the middle schools; after the second year both the division and state-level administrators withdrew all support. Although changes were made at the school level which supported reform in mathematics education (i.e., adoption of constructivist-type instructional materials, purchase of classroom sets of manipulatives and calculators, implementation of block scheduling, and the organization of teachers in interdisciplinary teams) the necessary changes in technology, curriculum and assessment were not in place to support the reform efforts. Through the perseverance of the Lead Teacher some changes in mathematics classrooms were documented, but the lack of consistent administrative leadership/support and emphasis on multiple reforms ended in the all to common bandwagon phenomena at the building, division and state levels so characteristic of change efforts in schools.

Acknowledgments

The accomplishment of this study is due to the work, support and cooperation of many individuals, and I would like to take this opportunity to recognize their contributions. First, I would like to acknowledge the participants of the study. Without their cooperation this study could not have occurred. My sincere appreciation and gratitude go to the following: (1) The Superintendent of [Pleasant] County Schools and the Principal of [Pleasant] Middle School, for consenting to participate in this research study on Systemic Reform, (2) The [Pleasant] Middle School teachers who volunteered their time and classrooms for this study; they welcomed me, my computer and my tape recorder into their classrooms and assisted me in every way possible in the data collection for this study, (3) All of the other [Pleasant] Middle School staff members that participated in this study (i.e., librarian, former Principal, science V-QUEST Lead Teacher, and the teachers who teamed with the mathematics V-QUEST Lead Teacher). They all took time to answer my questions and helped me in completing the Building-Level data collection portion of the study, (4) The Pleasant County administrators who scheduled time to participate in lengthy interviews and provided access to artifact data that facilitated data collection for all Levels for the study, and (5) All of the educators and administrators statewide who took time to prepare and share responses to my numerous questions about systemic reform at the State Level.

Second, I would like to acknowledge all of the people who supported this research effort from its conception to its completion beginning with my family, friends and colleagues. Special recognition goes to my mother and my husband who never gave up on me. They continued to provide what seemed like endless days of encouragement, support, and patience; all were desperately needed to see this project through.

Third, I would like to thank my Committee members, Dr. Patricia Kelly, Dr. John Burton, Dr. Ray Spaulding and Dr. Dr. Susan G. Magliaro for their continued support of this project and me.

Last, and most importantly, I would like to recognize the Chairman of my Committee, Dr. Robert Underhill, for the extraordinary amount of work he did in helping me complete this research project. Dr. Underhill's contributions to this work were crucial. For an extended period of time he shared his expertise, time and energy as he patiently and tirelessly edited and critiqued every step of this project. Much credit for the successful completion of this project goes to my teacher, supporter, editor, mentor, and friend: Dr. Underhill.

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Chapter I
A Historical Overview of Educational Reform and Rationale for this Case Study

A historical overview of educational reform before 1983 is presented at the beginning of this chapter to establish the recurring nature of educational reforms and their related goals. Schools have historically tired to achieve goals that were both a reflection of the needs of society and the needs of students, but agreement on what these needs actually were has proved to be elusive. Decisions concerning the goals of education and the goals of reforms vacillated between the arguments of who school should serve and how they should be served. Until 1983, decisions seemed always to have been presented as dichotomous choices.

When the social climate was conducive to change and a decision was reached concerning the goals of education, a new reform movement would emerge. Although the reform goals changed, the type of reform did not. For two centuries all the major reform movements used the same type of reform; only the implementation approaches varied. An overview of mathematics educational reform to 1983 provides a more detailed look at this particular type of reform movement and highlights the most commonly used implementation methods.

In 1983 the publication, *A Nation at Risk,* reported that U. S. schools were failing to meet the goals of education, thus, placing the country in economic jeopardy. International concerns became the driving force for reform. With America's place in the global community in question, educational reform was not just supported, it was demanded from every sector of society. The ten years that followed the publication of A *Nation at Risk* came to be known as the reform decade, and reform was prolific! A review of these reform movements chronicles the three waves of reform that followed *A Nation at Risk* and describes the evolution of the reconceptualization of reform. By 1989 planning for third wave reforms was underway, and reformers were once again grappling with the recurring issues of reform— the purpose of education, who it should serve and how they should be served. Due to a history of failed reforms, reformers were forced to look at these choices in a new way. Instead of viewing these issues as dichotomous choices, the question was reframed to "How can schools best educate all the people?"

Reform was reconceptualized around this inclusive view of education resulting in the reform method used in the third wave of reforms. This method, systemic reform, is identified and explained in the overview of 1990 reform methods, and the specific systemic reform movement addressed by this study is also identified and summarized. After systemic reform is defined, the need for studying systemic reform is then developed. The remainder of the chapter is devoted to explaining why a qualitative method of research, a case study of change in mathematics education of one middle school, was the best method for the study of systemic reform.

Brief History of Educational Reform in the United States

Demand for educational reform was not a new phenomenon on the educational landscape. Parker and Parker (1995) described the history of education in the United States as waves of school reform. Cuban (1990) claimed that the issue of the "inevitable return of school reforms" had become so familiar that it entered the folk wisdom of policy makers and practitioners. His discussion of recurring issues in educational reform debates included the same issues that appear in the 1990s educational reform movements: teacher-center classroom instruction versus child-centered instruction, academic curriculum versus practical curriculum, and centralized authority for governing schools versus decentralized authority.

Due to the recurring nature of educational reform and the accompanying debates, a historical perspective was an essential component for developing an understanding of any educational reform movement. This historical perspective will develop: (1) the recurring nature of reform, goals, issues and movements; (2) the relationship between social, economic and educational reform; and (3) the reasons why reform recurs. The historical background presented in this section will consist of three parts: (1) a limited overview of educational reform movements focusing on the general nature of, and major influences on those reform movements, and (2) a more detailed look into mathematics reforms movements of the recent past, and (3) the status of 1990s reform initiatives. This historical perspective will provide evidence of patterns in reform movements and help develop the theoretical framework of reform.

Overview of General Educational Reform from 1749 to 1983

A review of the history of educational reform revealed an interesting pattern of recurring issues, goals, and reform movements (Ansah, 1986; Cuban, 1990; Murphy, 1991; Parker, 1993; Parker and Parker , 1995). Recommendations for educational reform tended to be cyclical and to fall into predictable patterns. In the liberal periods such as the 1930s, 1960s and early 1970s, educational reforms focused on the needs of the disadvantaged. These reforms were designed to broaden schools' functions and to overcome their rigidity. In conservative times such as 1890s, 1950s, and 1980s, reforms tended to focus on the talented and were designed to emphasize basics and academics (Tyack and James 1983 as cited in Ansah, 1986). The educational dilemma, should education serve the elite or the masses, has not been resolved and thus, keeps reappearing in educational reform debates.

The roots of this educational reform issue, who education should serve, can be traced back to the conception of public schools and one of the first educational reform movements which originated in 1749. In this reform movement Benjamin Franklin challenged the educational system designed to serve wealthy elite males by advocating the use of academies which would be open to all students. He also recommended that these academies replace the traditional classical curriculum with a practical curriculum that had commercial relevance (Parker, 1993). This debate has resurfaced throughout the history of educational reform, and it was a topic of concern for the 1990s reform movements.

The various "waves" of reform movements experienced in education were not only cyclical, but were reflections of concurrent societal changes. Ansah (1986) described the relationship between society and education as symbiotic; changes in society create simultaneous changes in education. Educational reform movements from 1893 to 1960 provided examples of recurring educational reform and of the symbiotic nature of society and education. Between 1893-1895 the Committee of Fifteen on Elementary Education, the Committee of Ten on Secondary School Studies, and the Committee of College Entrance Requirements all recommended that mental discipline and the classical curriculum be the emphasis for all students (Ansah, 1986; Parker, 1993). This return to an emphasis on the traditional classical curriculum occurred just as the United States was changing from an agrarian society to a complex urban society and when schools were struggling to manage the influx of immigrants into the system (Parker, 1993).

These social conditions forced a shift away from the traditional view of education for select elite, to an acceptance of John Dewey's progressive education movement which focused on child-centered public schools with a broader practical curriculum (Parker, 1993). In 1918 the National Education Association published its Cardinal Principles report which reflected Dewey's progressive education theory. The report recommended that curriculum meet the changing socio-economic-political conditions of the time and suggested the following seven educational goals: health, command of fundamental processes, worthy home membership, vocation, worthy use of leisure, citizenship, and ethical character. A lack of qualified teachers, uncertainty of what schools should teach, how schools should be organized, and how these courses should be taught resulted in the failure of this progressive view of education. Dewey's broader curriculum took hold in relatively few suburban areas, and traditional education once again dominated U. S. schools (Parker, 1993).

Change was just as elusive for the Social Reconstructivist movement that attempted, in response to the extremism that resulted from Great Depression in the 1930s, to move progressive educators beyond child-centeredness and neutrality. George Counts and Harold Rugg, leaders of Social Reconstructivism, challenged educators to help students create a new social order by confronting socioeconomic-political problems, and proposing solutions. But educational emphasis, once again, returned to academic essentials and mental discipline with the school reforms urged by James Bryant Conant, President of Harvard University (Parker and Parker, 1995). He called for public agreement on public school goals and in 1959 for the consolidation of high schools to facilitate science and language laboratories, a varied curriculum, and high standards (Parker, 1993). International events, especially the Cold War and the launching of Sputnik, generated movements to reexamine subject matter and resulted in massive programmatic reform movements in the 1960s (Ansah, 1986). None of these movements proved to be successful in swaying traditional thought, and all soon declined from the educational scene (Parker, 1993).

The social unrest of the 1960s and heightened awareness of the educational needs of the disadvantaged and served as an impetus for the resurgence of the educational reform debate of who public education should serve, the elite or the masses. Congressional passage of the Great Society education package was a direct result of the public's acute awareness of poverty and the national trauma that was experienced with the assassination of President Kennedy. Focus of education and educational reform shifted from gifted-and-talented education to concern for the disadvantaged. Among the bills passed by Congress were the Economic Opportunity Act, which created Job Corps and Project Head Start, and the Elementary and Secondary Education Act (Chapter I), which provided supplemental educational funds for school districts based on the number of families living below the poverty level (Parker, 1993).

Before the Vietnam War drained away most of the funds, many school districts used Chapter I funds and other federal aid to build and implement Open Education classrooms. Open Education was a child-centered, neo-progressive movement based on the British infant schools and A. S. Neill's bestseller, *Summerhill* (1960, as cited in Parker, 1993). This movement was seen as an answer to the question of how public schools could reach, teach and save failure prone underprivileged minority children. By 1970 the Open Education movement began to decline being described by its critics as utter chaos. Its failure was attributed to lack of teacher training in the appropriate techniques and loss of financial support (Parker and Parker, 1995).

Education reform of the 1970s continued to focus on the disadvantaged but broadened in scope to include multicultural, bilingual, and special education for the handicapped and the learning disabled (Parker 1993). The importance of education was signified by President Carter in 1979 when he elevated the Department of Education to cabinet status. The next major reform movement was launched in 1983 by a report commissioned by Terrel Bell, Education Secretary, in an attempt to save the Department of Education from extinction (Parker and Parker, 1995).

This general overview of educational reform has established three points that have a bearing on 1990s reform movements: (1) educational reform movements, goals and issues are recurring phenomena, (2) social and economic conditions of society and educational reform are related, and (3) programmatic reform movements of the past have been ineffective in accomplishing sustained educational reform. The lack of sustained change in the system of education was due in part to the methods of implementation used by these reform movements. A more detailed look at these methods is provided by reviewing mathematics educational reform movements.

History of Mathematics Education Reform from the 1800s to 1983

The historical perspective of educational reform made it clear that the contradictory idea of progressive education and classical education resulted in each citing the other as the reason for needed improvements in schools and, consequently, to nearly constantly recurring reform movements. Prior to World War II the reforms in mathematics education simply mirrored the general reform movements and the results consistent with those movements. One of the first reform movements that specifically addressed mathematics education resulted from the public's reaction to U. S. preparedness for World War II. Taking the side of classical education, the 1893 Committee of Ten's recommendations for standardizing college entrance requirements were revived with the idea that more advanced studies of mathematics should be required in high schools. This reform resulted in curriculum changes that required the study of geometry and trigonometry for college bound students.

Not until the launching of Sputnik were mathematics educational reform initiatives pushed into the national consciousness (Fullan, 1993). Large-scale reform efforts devoted to improving mathematics and science education moved onto the educational landscape nationwide, but the focus was again on curriculum and mathematical content. Although New Math was based on a nontraditional conceptual theory of learning, the focus of the reform movement was on changing the curriculum and the content of the class and not on pedagogical education.

The three major movements in mathematics were New Math, Back-to-Basics, and Mastery Learning. All three of these reform initiatives focused on fixing the existing system of education by focusing on fixing the programs and/or fixing the teachers. A comparison of the implementation methods of these movements provides insight into the most commonly used methods of mandating and implementing educational reform: legislative mandate, programmatic or instructional mandates, inservice training for teachers', and teacher participation in summer institutes.

As mentioned previously, the 1957 launch of Sputnik, created a reactionary wave of educational reforms focused on improving students' performance in science and mathematics and winning the space race. Parker (1993) described the origin of these reform efforts stating, "Large funds (Sputnik "fear money") became available from the National Science Foundation. . ." (p. 9). Private foundations as well as federal agencies funded the study and development of the kindergarten through high school mathematics curriculum (Wilderman, 1976). The resulting mathematics program, New Math, was grounded in the new educational theories of Jerome S. Bruner. Despite the large expenditure of money and the involvement of subject matter specialists and professional educators, the massive reform effort was short lived.

New Math lasted for about a decade from 1960 to the early 1970s (Parker, 1993) before rumblings of dissatisfaction began to spread across the nation (Kolata, 1977). Due to criticisms from studies that detected a decline in students' abilities to perform basic arithmetic operations or to apply mathematics to real-life situations (Wilderman, 1976), and to funding cut backs, the conceptual approach to teaching mathematics was abandoned (Parker, 1993). Critics of the New Math movement claimed that New Math produced a generation of computational cripples, and that it was pedagogically wrong (Kolata, 1977).

In response to these criticisms, developers of New Math denied that test results demonstrated that students of New Math were subsequently less able to compute. They said that New Math programs were never properly implemented; thus, the test scores were not applicable to nor a result of New Math (Kolata, 1977). Analysts have not been able to agree on the reasons why test scores declined during the era of New Math, but they do agree that data from national achievement tests do not give a clear answer to the hypothesis that new math programs hindered students' abilities to compute. Although there is little detailed information concerning what was actually taught in mathematics classrooms between 1960 and 1970, most analysts believe that the mathematics taught was far more traditional than is generally believed (Kolata, 1977, p. 855). Developers of New Math and analysts do agree that crucial mistakes were made during the implementation phase of the New Math program (Kolata, 1977).

The Department of Mathematics Education of the University of Georgia (DMEUG) (1992) addresses this issue, lack of implementation of the New Math program, in the following statement:

> In the modern mathematics movement, the old mathematics curriculum was replaced by the new curriculum in the form of new school mathematics textbooks, and institutes were held for mathematics teachers to prepare them to teach the concepts and principles of the new curriculum. But little attention was given, in either the institutes or the new textbooks, to the nature of mathematical knowledge that would influence the practice of mathematics education. . . . The advocated methods, discovery learning (Hendrix, 1961) and discovery teaching (Davis, 1966), were viewed as having little to do with mathematical concepts *per se* . . . . (Hendrix, 1961 and Davis, 1966 as cited in DMEUG, p. 446)

James Fey (as cited in Kolata, 1977) was a developer of one of the New Math programs, University of Maryland Mathematics Project (UMMAP); he describes the attitude of developers towards the role of the classroom teacher as cavalier. “Developers of the programs assumed that if they wrote good books, teachers would use them successfully to teach their programs” (Kolata, 1977, p. 856). In an educational system that was often characterized with a factory metaphor where school is the factory, teachers the assembly line foremen, and students the products (Murphy 1991, p. 7), this assumption led to a mismatch between the mathematics curriculum and content and the teachers’ philosophical and pedagogical beliefs.

Failure to include philosophical and pedagogical instruction during summer institutes was not the only problem that contributed to New Math’s lack of implementation. NSF did not provide funding for the training of primary school teachers; thus, the teachers that were characterized as generally having poor mathematics backgrounds, as being poorly trained and even being the least academically inclined, where not prepared to teach New Math. The result was that they either ignored programs and taught in traditional ways or they stressed irrelevant points (Kolata, 1977). Other factors that contributed to the problem of New Math’s implementation were textbooks that were designed and developed without the input of classroom teachers, the exclusion of parents from the program, and a failure to consider the attitudes and reactions of parents and teachers to the New Math program (Kolata, 1977).

As the public’s dissatisfaction with the educational system of the 1960s grew so did the support for the Back-to-Basic movement. Declining test scores, a breakdown of discipline in the schools, the rising costs of education, and the drain of federal funds to finance the Vietnam War were catalysts for creating a social mood that demanded educational change. Fey (as cited in Kolata, 1977) writes that the Back-to-Basics movement was part of a general desire to recapture values of the past.

The advocates for New Math voiced concerns that the Back-to-Basics movement went too far in stressing computation and drill at the expense of other essential skills, and that the increased use of the hand-held calculator made this focus even less appropriate. Curriculum visionaries of the time pointed out that there was still a need for reform in the mathematics curriculum, but, based on the public's hostile reaction to the New Math movement and the social push to move Back-to-Basics, developers of mathematics curricula and representatives of funding agencies did not believe the public would support any wide spread curriculum reforms in the near future (Kolata, 1977). The trend of funding agencies proved this prediction to be true. Government funding was provided for inservice programs designed to help teachers who were already in the schools instead of large scale curriculum reform projects. NSF's budget request for 1976 included no requests for inservice funds, but Congress added money for these programs to the NSF budget anyway (Kolata, 1977). Fey (as cited in Kolata, 1977) questioned the valued of inservice programs stating that there is little hard evidence that inservice programs have been effective in improving mathematics education.

By 1976, attempts to strike a balance between the "new" and the "old" math were underway. Wilderman (1976) wrote:

> . . .today's mathematics programs are attempting to combine understanding and practice. Educators agree that reasonable understanding of number and process— supported by drill and practice— can lead to effective computational skills, while mere return to drill and rote memorization cannot. Now teachers are faced with the inevitable question: How can this combination mathematics best be taught? (p. 48)

Three basic organizational patterns emerged as methods of combining the concepts of New Math and "old math": individualized instruction, materials-oriented programs, and interdisciplinary programs (Wilderman, 1976).

Of these three approaches individualized instruction or Mastery Learning gained the most widespread attention and use. From 1968 to 1981, over 100 papers were published in journals or presented at conferences, and over 25 dissertations were devoted to the investigation of Mastery Learning (Caponigria, 1981). Implementation of Mastery Learning required minimal changes in the traditional classroom routines; thus, it received less resistance from teachers than other innovative techniques (e.g., New Math). In 1972, Benjamin Bloom's Mastery Learning teaching strategy received federal funding for purposes of institutionalizing the concept. By 1980 the project was judged to be a modest success with one of its future goals being to provide more inservice training opportunities to increase the number of teachers using Mastery Learning (Caponigria, 1981).

Both Mastery Learning and New math were programmatic reform movements that focused on the use of teacher training to implement and institutionalize the goals of the reforms. Mastery Learning used an inservice approach to institutionalize the use of the method where New Math used and institutional approach to train teachers in the use of the newly developed curriculum material. Although Mastery Learning was more successfully implemented than New Math, the reason was probably that the method fit into the traditional classroom and most of the teachers' efforts during inservice were devoted to constructing materials to use with this approach.

Mastery Learning was grounded in the traditional philosophy that students were empty vessels to be filled. The teacher's job was to provide information and the student's job was to absorb and memorize the information. Mastery Learning provided a structured system that teachers could use to help students acquire the knowledge being delivered. The optimal pattern for Mastery Learning consisted of a series of small units of material with clearly stated outcomes, each presented to the students by traditional techniques (lecture, modeling examples, and independent practice). These small units of instruction were followed by diagnostic quizzes, specific correctives, and then parallel diagnostic quizzes. The advantages over traditional instruction were frequent feedback and individualized instruction (Caponigria, 1981).

The disadvantages of Mastery Learning were that (1) the teaching of mathematics was fragmented into unconnected topics, (2) the focus of instruction was on procedures instead of the processes, and (e) there were no opportunities for students to make connections from one topic to the next. Mathematics was not connected to the real world, and critical thinking skills were neglected. Students scored well on computation tests but did not do well on problem solving. Students knew how to compute but did not understand when and where to apply the computation skills. This information became public knowledge and the topic of conversations across the United State was the 1983 publication, *A Nation at Risk*; this report was an indirect result of President Reagan directing Terrel Bell, the Secretary of Education, to reduce the cabinet-level Department of Education with the ultimate goal being its elimination. In an attempt to save the Department of Education, Bell appointed the National Commission on Excellence in Education (NCEE). In 1983 the NCEE completed *A Nation at Risk*. Everyone except Bell believed the report would gather dust, but the alarming phrases rang out in the nation's presses (Parker and Parker, 1995).

Among the demands for educational reform were higher academic standards, increased graduation requirements, and a longer school year. The report affirmed, and once again updated, the 1893 Committee of Ten and James B. Conant high school reports. Published as an open letter to the American people, newspapers and magazines across the

United States printed the full 32-page document. Bell generated discussions with educators and the public by taking the report on tour to regional meetings. As praise for the report mounted, President Reagan was forced to make a stand in support of public schools. A *Nation at Risk* succeeded in awakening the public to the need for educational reform, forcing the President to take an active leadership role in educational reform, and creating a social climate conducive to another round of educational reform (Parker and Parker, 1995).

Educational Reform from 1983 to the Present

The first section of this overview will elaborate on the so called "first wave" and "second wave" reform movements that were inspired by the publication of *A Nation at Risk*. Reform movements of the first wave were characterized by top-down state-mandate type reform movements that lasted until about 1985. The second wave of reforms, which were characterized by bottom-up school-based change efforts, lasted from about 1985 to 1990. The second section of this overview highlights the reconceptualization of reform and describes the resulting systemic reform movements that comprised the "third wave" of reforms.

Overview of the First and Second Waves of Reform

Proposals to improve education based on the recommendations made in *A Nation at Risk* were primarily top-down reforms that focused on raising academic standards by creating centralized controls (Murphy, 1991). The first wave of reform initiatives resulted in policies that emphasized higher academic expectations in secondary schools but ignored the problems of the at-risk students in elementary schools (Parker, 1993). Parker (1993) summarizes the accomplishments of the first wave of reform movements in the following statement:

> Three years after *A Nation at Risk* was published, 41 states had raised their high school graduation requirements, 33 states had initiated student competency tests, 30 states had begun to require teacher competency tests, 24 states had started teacher career and salary enhancement programs, and Scholastic Aptitude Test (SAT) scores had begun to rise. But the apparent gains proved disappointing. (p. 283)

In addition to these policies mandating minimum competency testing and stricter graduation policies, virtually all states made policy changes affecting teachers (Fuhrman, Elmore, and Massell, 1994). From 1980 to 1985, states considered over 1,000 pieces of legislation designed to change teacher policy. As teacher accountability became an issue of national concern, states enacted policies involving teacher certification and teacher working conditions. The number of states requiring some form of testing as a condition of teacher certification increased from 28 states to 46. Some states introduced recertification tests for veteran teachers and others required formal on-the-job assessment of teachers prior to licensure. Policies aimed at changing teachers' working conditions included career ladder approaches, master teacher, and merit pay programs (Fuhrman, et al., 1994).

Although these first-wave top-down reform efforts were reminiscent of the 1950s and 1970s attempts to upgrade students' performance in science, mathematics and foreign languages (Ansah, 1986), the amount of involvement by states and localities in policy making related reform was unprecedented (Fuhrman et al., 1994). Despite the high level of activity generated by education reform, it did not exert much influence over the processes of schooling, related to students' learning. Fuhrman, et al. (1994) summarized the progress of educational reform with the following observations:

> . . . by virtually all aggregate indices of performance, schools have shown little improvement since the beginning of the current period of reform. Academic achievement does not seem to have improved significantly over the past decade by most measures (National Center for Education Statistics [NCES], 1989, pp. 10-11, 14-15, 26-27). Even on those measures of academic achievement where some groups of students have shown improvement on basic skills, performance is extremely weak on the higher level problem-solving tasks that reformers value (Dossey, Mullins, Lindquist, & Chambers, 1988; Mullins & Jenkins, 1990). Dropout rates and rates of retention in grade have been stuck at unacceptable high levels for more than a decade (Frase, 1989; NCES, 1989 pp. 24-25; Sheppard & Smith, 1989). Indices of students' attachment to school, such as engagement and membership in school activities and workforce participation, show a high level of alienation among significant portions of school aged children (Wehlage, 1989; Wehlage, Rutter, Smith, Lesko & Fernandez, 1989). (p. 33-34)

Equating increases in policy making activity with increased influence over teaching and learning is a mistake (Fuhrman et al., 1994; Fullan, 1993). Critics of these top-down reforms movements claim they were unworkable because they failed to take into account the most fundamental variables in the educational process: the relationship between educators and their students and the extent to which students are actively engaged in the learning process (Sedlak et al., as cited in Murphy, 1991). The emphasis on prescriptions and performance measurement were at best piecemeal approaches aimed at repairing the existing educational system (Murphy, 1991). Another major criticism of the top-down standards-raising reform was that it increased the site and district bureaucracy and at the same time diminished the morale of school site personnel; these all crippled any efforts for real improvement (David, 1989 as cited in Murphy, 1991).

Response to the lack of success of the top-down mandated reforms brought about a rethinking of educational reform and the purpose of schooling. Reforms aimed at repairing the existing system were not working. Planning for the second wave of reforms was based on the idea that the traditional school system was not an effective model for meeting the needs of today’s society. The rhetoric of reform began to change to the language of restructuring. Goals of the second wave of reform changed to restructuring the traditional administrative structure of schools or altering the incentives under which schools operated. These bottom-up approaches to reform focused on school-level change and included reform initiatives such as school-based management and school choice (Murphy, 1991).

The goal of second-wave bottom-up reforms was to implement reforms designed to devolve some degree of control over curriculum, budget, or staffing to principals, teachers, and parents. The benefits expected from this approach according to Murphy (1991) included: “enhanced concern for equity issues Mojkowski & Fleming, (1988); stronger educational programs better student performance (Lindquist & Muriel, 1989; Mojkowski & Fleming, 1988); and greater satisfaction among school personnel and constituents (Lindquist & Muriel, 1989)” (p. 38- 39). These initiatives too, proved to be unsuccessful in changing the way schools did business. Fuhrman et. al., (1994) reported that changes in administrative structures occurred in a number of local districts, but there was little evidence that these changes were related to improvements in the quality of educational programs or student learning.

These multiple waves of policies, reform initiatives, and restructuring efforts did little to move education away from the philosophy of sorting students to fit the normal curve (Murphy, 1991). The historical view of educational reform showed the following three objectives of the various reform movements: fix the parts, fix the people, and fix the schools (Sashkin and Egermeier, 1992 as cited in Barley and Jenness, 1994). The problem was that change based on either one or some combination of these strategies was ineffective and any margin of success proved to be temporary (Barley, and Jenness (1994). Failures of the fragmented programmatic reform policies of the past indicated that systemic change was not only needed but that it was critical if educational reform was to be successful. Ansah (1986) wrote the following statement concerning programmatic reforms:

> The fact that educational reforms have become periodic is symptomatic of their lack of lasting success, and should be cause for concern. These factors (recurrence and lack of lasting success) are indications that we need to look

beyond programs and course content in our efforts to reform education. (p. 5)

Studies by the Consortium for Policy Research in Education (CPRE) of the first and second waves of reforms, which followed the publication of *A Nation at Risk,* found that the reforms lacked coherence and failed to encourage more challenging teaching and learning (see for example Clune and White, 1988; Clune 1989; Fuhrman, Clune and Elmore 1988; Firestone, Fuhrman and Kirst 1989 as cited in Fuhrman and Massell, 1992, p. 2). Based on CPRE's research and numerous consultations with policy makers, Marsahll Smith and Jennifer O'Day conceptualized a new vision for reform— systemic reform. The concept of systemic reform was based on the idea that schools have the ultimate responsibility for educating thoughtful, competent, and responsible citizens, while the states have the responsibility of defining what thoughtful, competent, and responsible citizens will mean in the future (Fuhrman and Massell, 1992). Thus, Smith and O'Day (1991 as cited in Fuhrman and Massell, 1992) proposed that systemic reform involved simultaneous increase of coherence in the system through centralized coordination and increase of professional discretion at the school site. This vision of reform, systemic reform, became the framework for the third wave of reform movements, which started in the late 1980s and continue today.

Third Wave Reforms: A National Perspective

Change in the purpose of schooling mandated a new model for the third wave of school reforms. The enduring traditional system of schooling was designed at a time when success meant fifteen percent of the students got a high quality education and the rest could read. This definition has drastically changed; success of today's educational purposes means that ninety-five percent of the students have a high quality education (Parker, 1993). Implications for reform were that policy makers needed to shift from designing controls, which were intended to direct the system, to developing the capacity of schools and teachers to be responsible for student learning and responsive to student and community needs, interest, and concerns (Darling-Hammond, 1994). The programmatic model used for the majority of reform movements in the past fit the behaviorist view of learning as the management of stimulus and response. School reform was based on the theory that researchers could discover the common procedures that would produce desired outcomes, and that changes in the design specifications for schoolwork would result in changes in the nature of education delivered in the classroom (Darling-Hammond, 1994).

Reconceptualization of school reform, which began during the second wave of decentralized or bottom-up reforms in the 1980s, resulted in a new paradigm for school reform. This paradigm was based on the assumptions that students are not standardized products and that teaching cannot be routinized. Teaching requires teachers to make judgments based on their knowledge of learning theory and pedagogy, of child development and cognition, and of curriculum and assessment (Darling-Hammond, 1994). If schools were going to be responsive to the different needs and talents of diverse learners, a reframing of the agenda for schools and school reform was necessary. Schools must be organized for variability rather than assuming uniformity. Teachers needed to diversify their practice and learn to foster meaningful learning experience that allow students to confront powerful ideas holistically.

Reform movements based on the philosophy that students are not "blank slates" waiting to be filled but are active participants in the learning process who construct their own knowledge in different ways depending on their previous experiences and how they perceive and interpret new information, requires a radically different approach (Darling-Hammond, 1994). Rather than attempting to make the current educational system more efficient by standardizing practice, school reforms needed to focus on building the capacity of schools and teachers to undertake tasks that they have never before been called upon to accomplish (Darling-Hammond, 1994). Darling-Hammond (1994) described the nature of new reforms with the following statement:

> Reforms that rely on the transformative power of individuals to rethink their practice and to redesign their institutions can be accomplished only by investing in individual and organizational learning, in the human capital of the educational enterprise— the knowledge, skills, and dispositions of teachers and administrators, as well as parents and community members. The new reforms also demand attention to equity in the distribution of those educational resources that build school capacity, including well-qualified teachers supported by adequate materials and decent conditions for teaching and learning. The dramatic inequalities that currently exist in American schools cannot be addressed by pretending that mandating and measuring are the same thing as improving schools. (p. 11-12)

Restructuring the school system involved changing the roles, rules and relationships between and among students and teachers, teachers and administrators, and administrators at various levels from the school building to the district office to the state level, with improvement of student outcomes being the ultimate goal (Sashkin and Egermeier, 1992 as cited in Barley, and Jenness, 1994). The second wave of reforms, which began in 1985, had restructuring education as the ultimate goal. To accomplish this goal there were two different theories of reform working in parallel— and sometimes at cross-purposes (Darling-Hammond, 1994).

The first theory called Theory X by Darling-Hammond (1994) and intensification by Barley and Jenness (1994) focused on tightening the controls. These reform movements consisted of more courses, more tests, more directive curricula, more standards enforced by more rewards and more sanctions. These top-down approaches assumed that the basic problems were the lack of focus, direction, and effort on the part of school people and that teachers cannot be trusted to make sound decisions about curriculum and teaching (Darling-Hammond, 1994).

Restructuring, the second theory (Barley, and Jenness, 1994), attended to the capacities of teachers, and to the development of schools as inquiring, collaborative organization (Darling-Hammond, 1994). Restructuring in contrast to intensification involved a release of tight controls to permit local decision making through such forms as site-based management, increased professionalization of teachers, restructured schedules and timetables, shared values and goals, and new roles for students, teachers, administrators, and policy makers. This new bottom-up paradigm of school reform's roots were in progressivism and sought to develop a community of learners (Barley, and Jenness, 1994).

Both theories were comprehensive with the intention of systematic change but they were philosophically and politically at odds (Barley, and Jenness, 1994). Darling-Hammond (1994) points out that, ". . . capacity building mechanisms— such as staff development programs, teacher education investments, and supports for school change— are funded much less well than activities designed to control the curriculum" (p. 14). She noted it was ironic that what we know about human learning had not informed the process of reform policy stating:

> Teachers are expected to change their beliefs, knowledge, and actions as a result of a change process that consists primarily of the issuance of a statement and the adoption of new regulations or curriculum packages. This approach to policy implementation clearly cannot achieve the goals of reform. (Darling-Hammond, 1994, p. 14)

Barley and Jenness (1994) stated that neither of these two competing movements were going to go away in the near future and that in fact real systemic change required the maintenance of a tension between top-down mandated standards and locally derived goals and objectives from the bottom-up movements. Systemic change, which pertains to "authority, relationships and the distribution and allocation of power and resources" (Rich, 1981 as cited in Ansah, 1986), encompasses both sides of the dichotomy (Barley and Jenness, 1994).

For systemic reform to be effective, Fullan (1993) wrote: "Assessment, curriculum and instruction, staff development, personnel selection and promotion, and state/district/school action— hitherto uncoordinated— are to be systemically linked" (P. 124). For this to occur it was necessary to combine bottom-up reform with top-down support. Fullan (1993) summarized the need for the joint effort of these approaches in the following paragraph:

> Neither centralization nor decentralization works. Centralization errs on the side of overcontrol, decentralization errs toward chaos. We have known for decades that top-down change doesn't work (Lesson 1: You can't mandate what matters). Leaders keep trying because they don't see any alternative, and they are impatient for results (either political or moral reasons). Decentralized solutions like site-based management also fail because groups get preoccupied with governance and frequently flounder when left on their own. . . . Two-way, top-down/bottom-up solutions are needed in which schools and districts influence each other though a continually negotiated process and agenda. (p. 128)

According to the Consortium for Policy Research in Education (CPRE, 1991) neither approach, top-down or bottom-up, was adequate for achieving successful reform when pursued in isolation. This publication indicated that Smith and O'Day (1991 as cited in CPRE, 1991) proposed a strategy for system-wide improvement that used a combination of both approaches in a supportive policy structure that provided direction for school-level changes and made such changes more easily adaptable to different school situations. The three major components of this strategy follow: a unifying vision and set of goals, a coherent instructional guidance system, and a restructured governance system. The report emphasized that policy structure is a function of state leadership, and that if more than a few schools or districts are to be influenced, the state must be a crucial actor in the reform process. Past reform failures and fragmented policies suggested that integration is critical for reform to be truly systemic (Fuhrman et al., 1994).

Third Wave Reform: Statewide Systemic Reform

NCTM and many researchers and policy makers claimed that systemic reform efforts were necessary for implementing successful and meaningful change in educational practices. After more than a decade of marginally effective reform, diverse stakeholders were coming to the conclusion that simply demanding more from our schools was not enough. The system itself must be fundamentally changed, and the piecemeal reform efforts of the past would not do the job (Thompson, 1994). Systemic reform was proposed as an alternative to what Thompson described as tinkering and add-on programs that would not meet the demands of business, parents, communities, and students for fundamental change and significant improvement in schools. V-QUEST (Virginia's Quality Education in Science and Technology) was an example of bottom-up/top-down systemic reform movement designed to improve the teaching and learning of mathematics and science in Virginia's classrooms.

V-QUEST was a statewide Systemic Initiative supported by the NSF and dedicated to ensuring that world class quality education in mathematics and science was available to every child in Virginia. Described as a vision for change, V-QUEST was based on the systemic reform concept that action must be taken on a number of fronts simultaneously because policies, programs, and reform initiatives all interact and are all interdependent (Lemahieu and Foss, 1994). V-QUEST's initiatives linked teachers, parents, school administrators, higher education, government, business, and industry into teams working together to plan and implement reforms. Seven components were structured to coordinate these efforts into simultaneous reform movements in the classroom, in school administration, in the community, in instructional material selection and design, in teacher training, and in assessment. In an unpublished article titled "V-QUEST Virginia's State Systemic Initiative" Robert Underhill, Coordinator for the Lead Teacher Component described V-QUEST's seven components and their goals as follows:

School-Based Mathematics and Science Lead Teachers: To have two lead teachers in every elementary and middle school in the Commonwealth.

New Pre-in-Service Models: To facilitate mathematics and science reform in grades 9-14 and to re-design all math and science teacher education programs.

Instructional Material Reform: To influence the design, marketing and use of all textbooks, software, and other resources for teaching math and science in K-14.

Local Educational Leadership/Administrative Support: To inform and gain support for reform from superintendents, principals and other key central administrator.

Community Action Campaign: To disseminate the V-QUEST vision and to mobilize numerous constituency groups into supportive action.

Communications Technology: To help communicate the V-QUEST mission across the state in all forms of media and to facilitate the use of all appropriate technologies in K-14 math and science instruction.

Since V-QUEST's ultimate goal was to change and improve the learning environment in the classroom, the Lead Teacher Program was an essential component for providing teachers with knowledge related to reform. V-QUEST's goals, instructional content, and instructional materials for reforming mathematics education were compatible with and based on the reform recommendations made by the NCTM. Guidance for curriculum reform in mathematics was provided by NCTM *Curriculum and Evaluation Standards*. Changes in pedagogy and teachers' beliefs that were necessary for implementing the recommended curriculum and content reform in mathematics education were provided by NCTM *Professional Standards*, and guidelines for reforming assessment practices so that assessment matched instructional techniques and expected educational outcomes were addressed in NCTM' *Assessment Standards*.

The Lead Teacher preparation program for mathematics was designed to educate teachers about the recommended reform issues, provide knowledge and a working support system for implementing these reforms into the classrooms, and develop leadership skills necessary for becoming leaders of reform in their schools and school divisions. Teacher preparation was a vital link in moving the entire educational system to a new level (Gregg, 1992), V-QUEST did not prescribe reform but provided teachers with the knowledge and skills needed to empower them to initiate appropriate reforms in their classrooms and schools. The Carnegie Forum's Task Force (1986 as cited in Corrigan & Mobley, 1990) stated that although many people play vital roles in reform, in the end only the people with whom the students come in contact with every day can do it. Textbooks, principals nor directives from state authorities can do it; only teachers can finally accomplish the reform agenda laid out (p. 12). Concerning mathematics reform NCTM (1991) wrote:

> Teachers are key figures in changing the ways in which mathematics is taught and learned in schools. Such changes require that teachers have long-term support and adequate resources. (p. 2)

For systemic reform to be successful in accomplishing enduring and meaningful change in the classroom, teachers must be empowered to act as professionals; this empowerment comes from professional development opportunities and administrative support (CORE, 1991; Ansah, 1986; Thompson, 1994; Gregg, 1992; Darling-Hammond, 1990).

This philosophy was consistent with the V-QUEST Systemic Reform Initiative and with the V-QUEST Lead Teacher program which served as the professional development component. The Lead Teacher program consisted of a two-week summer institute, monthly follow-up activities during the school year, two drive-in workshop experiences (one in the fall and one in the spring), and then a follow-up one-week institute during the next summer. The summer institutes were carefully planned using detailed guidelines of what content, pedagogical methods, instructional material, and leadership experiences must be offered.

According to Underhill's 1994 report, the time was broken down so that 25% of the time was devoted to leadership training that focused on adult learning, another 25% of the time was spent on understanding connections between mathematics and science, and 50% of the time was given to in-depth instruction in leadership, content and pedagogy. The day long drive-in workshops conducted during the school year addressed topics such as the use of technology in the classroom, equity issues, instruction on Virginia's Standards of Learning, grant writing, connecting mathematics and science instruction and provided share time for lead teachers and administrators.

An application process was used to select the school systems to participate in V-QUEST's Lead Teacher Institutes, and the administration (the superintendent and the school's principal) had to agree to support and participate in the reform movement efforts. This involved attending a portion of the summer institutes, providing mathematics and science with a larger portion of the instructional budget, and supporting lead teachers' attendance at professional conferences, and providing lead teachers release time from their classrooms for planning the implementation of mathematics reform in their schools. Underprivileged school systems and school systems that served large numbers of minorities were given first priority, but any elementary or middle school in the state of Virginia was eligible to apply to be a participant in the V-QUEST Lead Teacher Institutes. Two lead teachers (one science teacher and one mathematics teacher) were selected from each participating school. The requirements to be accepted as a Lead Teacher were a minimum of three years' teaching experience, a written recommendation by the school's principal, and willingness to commit time and effort to the V-QUEST reform program.

Need for This Study

The first rationale developed in this section is the need for this study of systemic reform and, more specifically, the need to study the outcomes of systemic reform in the classroom. Second, the rationale is made for why the study of systemic reform in mathematics education is an appropriate level of inquiry. To narrow the focus, these two rationales will be related to this case study of systemic reform in one middle school. It will be shown that the V-QUEST Systemic Reform Initiative was an example of the reconceputalized reform initiatives that characterized the third wave of reforms, and that it embodied the systemic reform recommended for implementing mathematics reform. Finally, the focus will be narrowed even further by explaining how the case study of change in the teaching mathematics in one middle school addressed the need for the study of systemic reform.

The Need to Study Systemic Reform

If the previously documented repetitive cycle of educational reform is to be broken, reform movements must be informed by past experiences and build on the knowledge to change the nature and approach of reforms. Cuban (1990) emphasized this point stating:

> Reforms do return again, again, and again. Not exactly as before or under the same conditions, but they persist. It is of even greater importance that few reforms aimed at the classroom make it past the door permanently. It is important to policymakers, practitioners, administrators, and researchers to understand why reforms return but seldom substantially alter the regularities of schooling. The risks involved with a lack of understanding include pursuing problems with mismatched solutions, spending energies needlessly, and accumulating despair. . . . We can do better by gathering data on particular reforms and tracing their life history in particular classrooms, schools districts and regions . . . . (p. 11-12)

Fullan (1993) wrote that the intensive study of change has essentially occurred only in the last half of the 20th century. With these studies wisdom about change processes has become increasingly sophisticated, and the focus for reform has become more comprehensive and deeper. He identified the following four themes of change that have occurred over the past four decades: 1960s— Adoption of Reforms, 1970s Implementation Problems, 1980s Multiple Innovations, 1990s—Systemic Reform (Fullan, 1993, p. 117). The first three themes set the stage for what we know and face for future educational reform while the fourth theme, systemic reform, reflects the complexity and comprehensiveness of educational changes (Fullan, 1993).

The need for research on the currently advocated systemic method of reform was clearly stated by Olson (1994) who wrote that the research on educational reform efforts does not suggest much about how to spread innovations successfully. The research in this area was so much documentation of failure it is hard to know what to make of it. Fullan (1993) reinforced this need for knowledge concerning educational reform stating progress has been made but that there was still not enough known about the dynamics of change. He noted that although we can identify and list “determinants of implementation,” we do not know how these factors interact and unfold. More information is needed concerning the “microprocesses” of successful change projects. Fullan identified a more fundamental need in the growing realization that knowing how one single innovation is implemented is not the complete story. He pointed out that schools are not in the business of implementing one innovation after the other but are in the business of implementing multiple innovations simultaneously (Fullan, 1993, p. 120).

Specifically addressing the need for knowledge concerning systemic reform Fullan (1993) wrote:

> We need concrete, knowledge— and skill-based examples of systemic reform in action in which actual connections are made through implementing new designs. (p. 130)

Fuhrman, and Massell (1992) stated that systemic reform was an unfolding agenda for policy and continuing subject for policy research. Darling-Hammond (1990) noted that systemic reforms aimed at structural reform should be followed-up by serious inquiry concerning the nature and causes of educational performance in American schools, the evaluation of reform strategies informed with an understanding of how schools operate, what the outcome of various new incentives and initiatives are and what the ingredients are for sustained and meaningful change (p. 287).

Clarifying her recommendation concerning research and systemic reform Darling-Hammond (1994) shared the following observations:

> Continued research that digs deeply into the textures of teaching and the nuances of teachers' thinking will augment our understanding of subject-matter pedagogy; of curriculum building; of teacher learning; of student learning; of links between intelligence, performance, assessment, and classroom practice; and successful teacher education. Such research can also help create more meaningful and sensitive assessment of teachers' knowledge for licensing, certification, and evaluation systems. . . . State licensing and evaluation standards that embody conceptions of the type of teacher knowledge needed for adaptive and reflective practice are key to building the foundation of a new model of school reform. (p. 20-21)

The bottom-line reason for studying systemic reform was to determine if the complex and comprehensive approach that tackles all components of the educational system at once will effect any real change in the classroom. Much of what systemic reform hopes to accomplish involves changes in policies and attitudes— intangibles that are difficult to measure (Zurer 1994). In 1993 Congress was supportive of the systemic reform movement, but if support was to be maintained success must be the outcome. Studying the result of systemic reform is the only way to document success. NSF's Office of systemic reform which was under the Driectorate of Education and Human Resources, had a budget of $110 million in the 1994 fiscal year (Zurer, 1994). Ongoing Statewide systemic reform Initiatives dedicated to improving mathematics and science education accounted for most of the expenditures of that budget. If these funding trends continue, this budget will only grow, thus, increasing the need to know if systemic reform will actually change what is happening in the mathematics classrooms.

The Need to Study Systemic Reform of Mathematics Education

Advances in technology have caused the country to shift from an industrial to an information society. The move toward a postindustrial society has transformed our concepts of essential mathematical content and mathematical concepts and procedures (NCTM, 1989). Another factor contributing to the need for change in mathematics education was the decrease in the number of surplus students in conjunction with the increase in the level of skills required by workers. Thus, the economy demands that schools radically redesign their operations (Murphy, 1991, p. 7). According to the National Council of Teachers of Mathematics (1989) ". . . the pace of economic change was being accelerated by continued innovation in communications and computer technology" (p. 3). Due to the resulting social and economic changes the educational system of the industrial age no longer met today's economic needs. Educational outcomes are no longer insignificant but are now major concerns for education and the nation (NCTM, 1989, p. 3). NCTM has provided the necessary leadership for making the essential changes in mathematics education.

Reform means to reshape, to reconfigure, to make different, but mere change does not necessarily mean improvement (Shubert, 1993). The National Council of Teachers of Mathematics (NCTM) took a leadership role in the academic disciplinary field by providing guidance for the direction that systemic reform needed to take to make improvements in the teaching and learning of mathematics possible. Although NCTM voiced concerns about the status of mathematics education and proposed bold recommendation for change in *An Agenda for Action* in 1980, it was not until after the highly publicized *A Nation at Risk* that the public was ready for change. In response to the problem of low student achievement in mathematics and lack of readiness for meeting the economic needs of the future, NCTM took unprecedented action by coming to a consensus and publishing national goals. These goals included challenging student outcomes, professional expectations of teachers to enable students to meet these outcomes, and recommendations for assessment that match the recommended goals (Frye, 1990).

NCTM's view of mathematics education paralleled society's changed view of the purpose of education in that high academic standards are not reserved for the elite student but are expected of all students. Frye (1990) wrote that, "In terms of program, the *Curriculum Evaluation Standards for School Mathematics* (*Standards*) (NCTM, 1989) serves as a hallmark in our movement to make mathematics accessible to all students and to develop curricula that will be responsive to the needs of the broader community of business and industry" (p. 499). The NCTM took a proactive role in determining the course of future trends in the discipline of mathematics by developing cohesive plans for making realistic changes in four areas of mathematics education: program, process, progress and product (Frye, 1990).

Supplying the concrete goals was only the first step in accomplishing educational change. The real test comes in implementing the standards. Traditional mathematics instruction designed around basic skills and rote memorization has remained intact despite fifty year of intensive mathematics reform efforts. One of the major concerns was that the national standards will produce superficial reform instead of the structural reforms needed to achieve true educational change (Darling-Hammond, 1990). NCTM laid the groundwork for structural changes through the use of systemic reform by integrating changes in curriculum, assessment, instruction and suggestions for the restructuring of schools to support these changes.

The conclusion that today's schools do not meet the needs of today's children was supported by what the American Association for the Advancement of Science (AAAS, 1989) described as a "cascade of studies." Based on national standards and world norms, these studies indicated that "U.S. education is failing to adequately educate too many students. ." (AAAS, 1989, p. 3). The following studies supported the conclusion that the 1990s educational system was inadequate and did not meet the needs of students: Piazza (1994); Brown (1991); Dobson, Dobson, & Koetting (1985); Forester & Powell (1992); Salz (1990). Numerous reports not only confirmed the need for educational reform but offered guidance and recommendations for the reform process (e.g., *A Nation at Risk; The Imperative for Educational Reform* (1983*); Action in the States: Progress Toward Education Renewal* (1984); *A nation Prepared: Teachers for the 21st Century*. *Productive People Productive Policies*. (1986); *Making America Work Bringing Down the Barriers* (1986); *Professional Standards for Teaching Mathematics* (1991); *and Assessment Standards for School Mathematics* (1995). All of these reports addressed the need for educational reform, and the last five offered specific directions and recommendations for educational reform in mathematics.

In response to these national demands for reform in science and mathematics education, the National Science Foundation (NSF) spent millions of dollars in support of state, urban and rural systemic reform initiatives (Zurer, 1994). Zurer (1994) described the reform initiatives that NSF chose to fund as reform movements that were designed to take the comprehensive approach of attacking all components of the educational system at once and encouraging cooperation among school systems, parents, local business communities, universities, and institutions which provide informed education (p. 25). NSF was encouraging the educational establishment to simultaneously implement improved curricula, teacher enhancement programs, innovative testing methods , and policies that supported change (Zurer, 1994). Zurer (1993) wrote that NSF's funding trends indicated that "NSF no longer wanted to support isolated, piecemeal projects whose benefits never spread beyond the school or classroom where they were developed" (p. 25).

Zurer (1994) shared the following quote from Shirley Malcom, head of the AAAS' education and human resources effort, in support of NSF's choice to "stake millions" on the success of systemic reform movements. Malcom (as quoted in Zurer, 1994) stated:

> With systemic reform, for the first time we are really trying to address all the critical issues. . . . People have been saying: We need better curricula. The teachers need training. We need good material. Yes, yes, and yes! But those are only part of the puzzle. We need to change policy. We need to change the system that doesn't believe all kids can succeed. (p. 26)

<u>Rationale for Studying Pleasant Middle School to Document Systemic Reform</u>

V-QUEST was one example of the systemic reform movements in the third wave of reforms. As a systemic reform movement in mathematics, it was grounded in the philosophies and educational theories recommended by the NCTM *Standards* and embodied the reconceptualized view of reform. The reform movement was based on the idea of providing the best education for all students, and was designed on a bottom-up with top-down support systemic reform approach.

V-QUEST's first two-week Lead Teacher Institutes were held in the summer of 1993. Three different institutes were held at various locations across the state of Virginia. A total of 240 elementary and middle school math and science teachers and 120 principals participated in these institutes. These 240 teachers graduated from the Lead Teacher program the following summer by completing the one-week follow-up V-QUEST Institute. A network of lead teachers was formed that reached across the state of Virginia. Two of these Lead Teacher graduates were from Pleasant Middle School.

Systemic reform was not a quick-fix approach for educational change. Gann (1993) documented that change was a two or three year process that moves through three different levels or phases: initiation phase, implementation phase, and institutionalization phase. Experts do not all agree on this time frame; Olson (1994) discussed different estimates that ranged from two to six years but all agreed that change takes time and sustained change was dependent upon the passage of time.

Since Pleasant Middle School lead teachers participated in their first two-week V-QUEST Lead Teacher Institute in the summer of 1993, the 1995-96 school year fit the time frame for mathematics reform to have occurred, specifically change in the what the teachers do in mathematics classroom and program changes.

Two pilot studies conducted in the 1994-95 school year documented that Pleasant Middle school was actively involved in educational reform efforts. One pilot study pertained to the joint restructuring process of the two middle schools in Pleasant County, Duncan Middle School and Pleasant Middle School. Two observable results from the study of this restructuring process were: (1) a change in the school schedule, and (2) the development and consensus of a mission statement for the middle schools. The middle schools moved from seven 48-minute class periods each day to a more flexible block schedule with 90-minute class periods. The mission statement which was in agreement with the premises that all students can learn and the philosophy that all students should receive a high quality education follows:

> Pleasant County Middle Schools are dedicated to providing a quality learning-centered environment in which all students have an opportunity to develop: a commitment to life-long learning; respect for themselves and others; social, emotional and physical health; and academic and communication skills necessary to become a responsible citizen. (Pleasant County Restructuring Committee, 1994)

The second pilot study, "The Effective Middle School Mathematics Teacher," was a two-week study conducted in the Pleasant Middle School's lead mathematics teacher's classroom. This study documented that the mathematics instructional materials and textbook, *Glencoe's Mathematics Application and Connections*, that were used in the classroom were based on the NCTM *Standards'* recommendations. The textbook initially adopted and put into use during the 1992-93 school year was correlated with the NCTM's Standards and designed to assist teachers in engaging students in mathematics education that developed positive student attitudes towards mathematics. The goals of the textbook were to convince students that mathematics was an important part of their everyday lives and that it was relevant to other subjects. Instructional techniques encouraged by the textbook included the use of projects, small and large group learning hands-on learning activities and pedagogy based on the constructivist philosophy and cognitive learning theories (*Glencoe*, 1993, P. T1-T23).

This pilot study also documented that traditional mathematics instruction was not the predominate method of instruction practiced in the lead teacher's classroom during the two weeks of observation and that authentic forms of assessment were used. Interviews conducted indicated that the Lead Teacher was active in professional organizations and acquainted with the NCTM documents guiding reform efforts. Direct involvement in three meetings held by the Pleasant County School Board during the 1995-96 school year verified that Pleasant Middle School's mathematics lead teacher was taking an active role in current reform efforts. These efforts involved rewriting the mathematics curriculum to match Virginia's new *Standards of Learning* and selecting new assessment materials to match the expected learner outcomes.

All of these data indicated that Pleasant Middle School was involved in reforming mathematics education and that the mathematics lead teacher was participating in these activities. As documented in the historical review of educational reform literature, reforms seldom go beyond getting adopted as policy, and most get implemented in word rather than deed especially in classrooms (Cuban, 1990). Reform often results in signs of reform (i.e, new rules, different tests, revised organizational charts, and new equipment). Cuban (1990) noted that:

> Seldom are the deepest structures of schooling that are embedded in the schools; use of time and space, teaching practices, and classroom routines fundamentally altered even at those historical moments when reforms seek those alterations as the goal. The itch may be real but the stroking is gentle. (p. 9)

A case study of Pleasant Middle school was a small step towards verifying whether systemic reform moved past words and signs and into the classrooms.

Chapter II
Review of the Literature

The purpose of this study was to document systemic reform of mathematics in one middle school that participated in the V-QUEST Lead Teacher Institute. The reforms recommended and encouraged by V-QUEST were based on NCTM *Curriculum, Professional* and *Assessment Standards* which were designed to promote a new, shared vision of mathematics teaching and learning. Consequently the criteria designed to analyze data to document systemic reform were based on the NCTM *Standards*. Since an extensive review of the three volumes of the NCTM *Standards* is provided in Chapter Three with the methodology and analysis procedures, and Chapter One provided a review of the literature related to methods of reform, the literature review for Chapter Two focused on research and literature related to the mathematics educational reforms recommended by the NCTM *Standards*.

This review begins with a presentation of the constructivist theory of learning to provide the underlying support for the instructional changes recommended. This is followed by research and literature related to pedagogy characteristic of constructivism and how they differ from the traditional behaviorist beliefs and methods that are to be replaced. The review of the literature concludes with a summary of findings and recommendations for documenting NCTM related reform in mathematics classrooms. Documenting Systemic reform required a multilevel study with a broad focus (curriculum, assessment, pedagogy, instructional materials, technology, changing beliefs, and administrative leadership); therefore, for the purposes of clarity and impact, many of the pertinent research results reviewed for this study are presented with their related topics as appropriate.

Constructivist Theories of Learning

Although constructivism is the driving force of mathematics reform, and the constructivism movement is widely accepted and supported as the philosophy for improving mathematics education, its appearance as a unified reform effort for mathematics education is deceiving (Cobb et al., 1992). It is really a heterogeneous movement, and in a recent review Matthews (1993) identified the thirteen varieties of constructivism that follow: contextual, dialectical, empirical, information-processing, methodological, moderate, Piagetian, postepistemological, pragmatic, radical, realist, social and sociohistorical. Despite the numerous versions of constructivism, its ontology is largely realist—the world although unknowable does actually exist apart from our thinking about it, but there are the idealist constructivists, such as Ernst von Glasersfeld, who believe—the world is created by human thought and dependent upon such thought (Matthews, 1993, p. 362). Applied specifically to mathematics, the realist believes that there is a true mathematical knowledge that has some sort of existence outside the mind of the individual, whereas the idealist believes that mathematics only exists in the mind, and that there is no perfected mathematical knowledge waiting to be discovered.

Simon (1993) describes the philosophy of constructivism that mathematics reform is based on:

> Constructivism derives from a philosophical position that we as human beings have no access to an objective reality, i.e., reality independent of our way of knowing it. Rather, we construct our knowledge of our world from our perceptions and experiences which are themselves mediated through our previous knowledge. Learning is the process by which human beings adapt to their experiential world. (p. 5)

There are numerous descriptions of the constructivist's philosophical positions on the nature of mathematics and on the nature of learning and knowing mathematics. There are many variations on the constructivist theory of learning, but there seems to be only one serious point of contention: the role that social interaction plays in the learning of mathematics. Is learning fundamentally a social process or a cognitive process? A comparison of the three most prevalent constructivist theories (Piagetian, radical, and social) found in the review of the literature on the issue of social interaction revealed the constructivist's commonly held beliefs about teaching and learning and agreed-up espitmology. The review of literature related to the constructivist's theory of learning is followed by literature and research related to the constructivist reform movement in mathematics and documenting reform in the classroom.

Piagetian or Idealist Constructivism

Piaget is generally regarded as a foundational figure of constructivism, and the following quote from Piaget (as cited in Phillips, 1995) is used to describe his constructivist theory of learning:

> Fifty years of experience have taught us that knowledge does not result from a mere recording of observations without a structuring activity on the part of the subject. Nor do any a priori or innate cognitive structures exist in man; the functioning of intelligence alone is hereditary and creates structure only through an organization of successive actions performed on objects. Consequently, an epistemology conforming to the data of psychogenesis

> could be neither empiricist nor preformationist, but could consist only of a constructivism. (Piaget, 1980, p. 23, as cited in Phillips, 1995, p. 6)

Piagetian or idealist constructivism has its roots in an evolutionary biological metaphor, according to which, the evolving organism must adapt to its environment in order to survive, and the developing human intelligence must also undergo a process of adaptation in order to fit with its circumstances and remain viable (Earnest, 1994, p.20). Piagetian constructivists' approach to knowledge and learning claims that while absolute knowledge of reality is impossible, theories can be constructed that are successive approximations of this reality. Learning is described as the acquisition of schemata through assimilation and accommodation. A schema is a cognitive structure that represents mathematical concept or set of concepts. This concept requires a presupposition that mathematical knowledge can be mapped out in a way that reflects its innate structure (Kloster and Dawson, 1991, p. 75).

Radical Constructivism

Ernst von Glasersfeld is renowned in the contemporary international science and mathematics education communities for his theory of radical constructivism. He described the radical constructivist's theory of learning as a traditional myth explaining that the content of our knowledge results from free creation of our culture (Phillips, 1995). In radical constructivism acquiring knowledge is a process of providing structure and organization to the world in an effort to "make sense" of experiences. Von Glasersfeld (1984) writes that our knowledge can never be interpreted as a picture or representation of the real world but only a key that unlocks possible paths for us (p.18).

Von Glasersfeld (1984) also explained the difference between these two philosophies by pairing the words "match" and "fit". Realist look for knowledge that *matches* reality, knowledge of the world, an equivalence of relations, a sequence or a characteristic structure. If you insert the word *fit*, then there is a different relation as when a key fits a lock. The fit describes a capacity of the key, not of the lock (p. 20-21). In further clarification of this distinction he writes:

> Radical constructivism, thus, is radical because it breaks with convention and develops a theory of knowledge in which knowledge does not reflect an 'objective' ontological reality, but exclusively an ordering and organization of a world constituted by our experience. . . .(p. 24)

von Glasersfeld's individualism and subjectivism in espistemology leads to the argument that mathematics students are responsible for building his or her own set of understandings, and teachers cannot assume that all students have the same set of understandings, or that their own ways of understanding are shared by their students

(Confrey, 1990). The radical constructivist sees social interaction as an important context for learning, but the focus is on the resulting reorganization of individual cognition (Simon, 1993).

Social Constructivism

This theory of learning is grounded in Vygotsky's philosophy of learning. Unlike Piaget's developmental theory of learning, Vygotsky (1978) does not believe that learning is subordinate to development, and he also rejects the idea of learning being development, in which learning is perceived as the process of elaborating innate structures (as cited in Steffe and Tzur, 1994). Vygotsky shares his views concerning his understanding of the relationship between learning and development in his general genetic law of cultural development saying:

> Any function in the child's cultural development appears twice, or on two planes, First, it appears on the social plane, and then on the psychological plane. First it appears between people as an interpsychological category. This is equally true with regard to voluntary attention, logical memory, the formation of concepts, and the development of volition . . . It goes without saying that internalization transforms the process itself and changes its structure and functions. Social relations or relations among people genetically underlie all higher functions and their relationships. (Wertsch and Toma, 1994, p.162 as cited in Steffe and Tzur, 1994, p. 28)

Steffe and Tzur (1994) describe the assumption that individual learning is dependent on social interaction as one of the basic tenets of the Vygotskian approach to education and explained that Vygotsky proposed that the qualities of thinking are actually generated by the organizational features of the social interaction (p. 29). Individual mental functioning is not envisioned as a simple and direct copy of social interaction because of the genetic transformations involved in internalization. Internalization is seen as the fundamental process involved in learning. This internalization makes it possible to hypothesize personal forms of cultural meanings of mathematics. It is also believed that the generalized knowledge and skills for dealing with the world have been built up throughout cultural history and can be transformed into curriculum content which can be taught. The distinction is made, however, that personal meaning cannot be taught directly and can only be built up by the involvement in an educational relationship. Vygotsky stressed that cultural meaning can become intermingled with personal sense through an educational process (Steffe and Tzur, 1994, p. 29).

Kamii and Lewis (1991) provide an example of how this cultural knowledge, and personal knowledge relates to the learning of mathematics. They claim the ultimate sources of social knowledge, or in Vygotsky's terms personal sense, are conventions worked out by people, and offer these examples of social knowledge:

> . . . the fact that Christmas comes on the 25 December and that a tree is called *tree*. The spoken words *one, two, three*, as well as such written numerals as 1, 2, 3, belong to social knowledge, but the numerical concepts underlying these conventions belong to logico-mathematical knowledge. (Kamii and Lewis, 1991, p. 8)

Social constructivists see higher mental processes as socially determined. Learning or individual knowledge derives from the social dimension which means knowledge resides in the culture, and the system is greater than the sum of its parts (Simon, 1993).

Both radical and realist constructivism incorporate the beliefs of social constructivism. A comparison of the learning theories of the realist constructivism of Piaget and the radical constructivism of Ernst von Glasersfeld shows the variation in the philosophies behind the constructivist theory of learning, and, also, their common beliefs about teaching and learning. Despite the underlying philosophical differences of Piagetian radical and social constructivism these core epistemological principles are common to the constructivists' learning theories (Osborne and Wittrock's, 1985 as cited in Matthews, 1993):

> (1) Knowledge is actively constructed by the cognizing subject, not passively received from the environment; and
>
> (2) Coming to know is an adaptive process that organizes one's experiential world; it does not discover an independent, pre-existing world outside the mind of the knower. . . .
>
> (3) The learner's existing ideas influence what use is made of the senses, and in this way the brain can be said to actively select sensory input.
>
> (4) Learners' existing ideas will influence what sensory input is attended to and what is ignored.
>
> (5) The input selected or attended to by the learner, of itself, has no inherent meaning. (p. 362-364)

Taking a constructivist's view of learning mathematics means that numbers are made by learners, not found or accepted from adults. Mathematical learning occurs when changes are made in the learners' schemes or structures. These changes are produced by the cognitive processes of assimilation, accommodation, and reflective abstraction (Steffe, Cobb, and von Glasersfeld, 1988). This constructivist view of learning mathematics is accepted almost universally by mathematics educators, but it is doubtful that any take the representational view literally and believe that learning is a process of immaculate perception (Cobb, Yackel, and Wood, 1992, p. 3). If that were the case, then we would not need to be concerned with theories of learning.

Planning of instruction, based on a constructivist view of learning, means that students must have freedom to make responses to the situation based on their past knowledge of the context and their developing mathematical understanding (Simon, 1993). No *real* learning takes place if the situation simply leads students to a particular response. The type of learning that takes place is how to respond appropriately to the teacher's leading questions. The creation of appropriate problem contexts should allow pupils to use ideas beyond the narrow context of the original problem situation. It should also provide for "situations for institutionalization"—ideas constructed, or modified, during problem solving attain the status of knowledge in the classroom community. It is the responsibility of the teacher to foster the development of conceptual knowledge, and to facilitate the construction of shared knowledge in the classroom community (Simon, 1993, p. 10-1).

Richards (1991; as cited in Simon, 1993) describes the mathematics instruction required of teachers to foster students' construction of powerful mathematical ideas in the statement that follows:

> It is necessary [for the mathematics teacher] to provide a structure and a set of plans that support the development of informed exploration and reflective inquiry without taking initiative or control away from the student. The teacher must design tasks and projects that stimulate students to ask questions, pose problems, and set goals. Students will not become active learners by accident, but by design, through the use of the plans that we structure to guide exploration and inquiry. (p. 8)

In the NCTM *Standards* (1989) teachers are described as encouraging students, probing for ideas, and carefully judging the maturity of a student's thoughts and expressions. Problem situations created by the teachers must keep pace with the maturity—both mathematical and cultural—and experience of the students. Instruction should be developed from these problem situations. The problems should be designed so that students can develop a framework of support that can be drawn on in the future. While it is often necessary for teachers to focus on specific concepts and procedures, mathematics must be approached as a whole. Concepts, procedures, and intellectual processes are interrelated; thus, the teacher should make deliberate attempts to connect ideas and procedures among different mathematical topics and with other content areas (p. 10-11).

von Glasersfeld's (1990) words were used to emphasize how this constructivist learning environment is created:

> The task of education...becomes a task of first inferring models of the students' conceptual constructs and then generating hypotheses as to how the students could be given the opportunity to modify their structures so that they lead to mathematical actions that might be considered compatible with the instructor's expectations and goals. (von Glasersfeld, 1990, p. 34, as cited in Pirie and Kieran, 1992, p. 506-7)

Constructivism and the Mathematics Reform Movement

Constructivism as a theory of cognition provides teachers of mathematics an alternative to the traditional objective view of mathematics education. The traditional view of teaching mathematics is based on the behaviorist philosophy that mathematics can be learned through mathematical precision and rigor (Carpenter, 1989, p. 226, as cited in Kieran, 1994, p. 597). The underlying beliefs of this philosophy are that learners are passive receivers of knowledge (Kieran, 1994, p. 588), and that the teaching and learning of mathematics is the effective transmission of an adequately coded message which is received and decoded by the learner and then represented internally (Ernest, 1994, p. 20).

This traditional theory did not provide a pedagogical model for developing understanding (Kieran, 1994, p. 597); thus, procedural knowledge and conceptual knowledge were divorced. Learners had difficulty applying the mathematical procedures learned in school to problem solving situations, and the learners made no connection between the mathematics learned in school and the mathematics used outside of school. Teachers struggled with the problems of motivating students to learn mathematics and attempting to answer the question: When will I ever need this?

According to Henningsen & Stein (1997), during the past decade there has been much discussion and concern focused on the limitations in students' conceptual understanding as well as on their thinking, reasoning and problem-solving skills (Hiebert & Carpenter, 1992; Lindquist & Kouba, 1989; National Research Council 1989). The underlying goals of NCTM's published reforms of curriculum, assessment, and instruction are to enhance students' understanding of mathematics and help them become better mathematical doers and thinkers (Henningsen & Stein, 1997, p. 524).

Henningsen & Stein describe doers and thinkers of mathematics as follows:

> . . . This dynamic stance toward mathematics requires one to focus on the active, generative processes engaged in by doers and users of mathematics (Schoenfeld, 1992), rather than view mathematics as a static, structured

system of facts, procedures and concepts. Such active mathematical processes involve the use of mathematical tools systematically to explore patterns, frame problems and justify reasoning processes (Burton, 1984, National Research Council, 1989, Romberg, 1992; Schoenfeld, 1992, 1994) (p. 524-5)

The emphases in traditional teaching is on practicing the manipulation of expressions and on practicing algorithms as a precursor to solving problems and ignoring the fact that knowledge often emerges from the problems. It is suggested (NCTM 1989, 1991,1995; 1994; National Research Council, 1989; Romberg, 1992; Schoenfeld, 1992,1994.) that the traditional view, of students mastering computations before working with word problems, be reversed so that experience with word problems can help students develop the ability to compute. In this way, students may recognize the need to apply a particular concept or procedure and have a strong conceptual basis for reconstructing their knowledge at a later time.

With national concern aroused by the publication of *A Nation at Risk*, the time was ripe for the supporters of constructivism to exert influence on mathematics' pedagogy and curriculum. Kieran (1994) writes that although constructivism has always been with us, perhaps under another guise, its support as an educational tenet grew rapidly for the previous decade. Constructivism is more than just a psychological theory about human learning, it has significant philosophical and methodological components (Matthews 1993, p. 361). Acceptance of the constructivist philosophy of education brings with it influence on educational research, theories of learning, methods of pedagogy, methods of assessment, curriculum design, and, hopefully, it influences teacher education and the design of educational programs. Acceptance of constructivism changes the view of teaching mathematics; it no longer means teachers transmit knowledge and that learning mathematics means reception of that knowledge and the subsequent capacity to regurgitate what was taught— the zenith of constructivism (Kieran, 1994, p. 598).

Phillips (1995, p. 5) writes that educational literature on constructivism is enormous and that it is growing rapidly; a significant indicator is that the 1993 AERA Annual Meeting Program contained more than a score of sessions explicitly on the topic of constructivism. Constructivism's influence in research was evident by the replacement of the behaviorist paradigm for research by a constructivist paradigm. There was a noticeable increase in the number of constructivist based research studies in the conference proceedings of the l International Group for the Psychology of Mathematics Education (PME), and the same trend was noticed in most of the mathematics education journals including the NCTM's. In 1990 NCTM published an Anthology on Constructivism in Mathematics Education (Davis et al., 1990, as cited in Matthews, 1993, p. 359). Qualitative studies came to the fore front, and there was even an openly expressed need for such studies. With the shift of focus from student achievement to learners processes and conceptual understanding, standardized achievement scores no longer provided adequate data for developing learning theories that could improve classroom instruction and learning.

The NCTM *Curriculum and Evaluation Standards for School Mathematics* (1989) serve as guide for mathematics reform and support the constructivist theory of learning with research findings from psychology which indicate that learning does not occur by passive absorption alone (Resnick 1987). Instead, it is suggested that when individuals approach a new task with prior knowledge, they assimilate the new information and construct their own meanings. New ideas will only be accepted by learners when their old ideas do not work or are inefficient. These findings go on to point out that ideas are not isolated in memory but are organized and associated with the natural language that one uses and the situations one has encountered in the past. For effective teaching and learning to occur in mathematics this constructivist theory of learning must be reflected in the way much of mathematics is taught (NCTM Standards, 1989, p. 10).

The constructivist theory of learning is embedded in these three tenets of the NCTM's (1989, p.7) recommended reform as follow:

(1) "Knowing" mathematics is doing mathematics.

(2) Some aspects of doing mathematics have changed in the last decade.

(3) Changes in technology and the broadening of the areas in which mathematics is applied have resulted in growth and changes in the discipline of mathematics itself.

"Knowing mathematics is doing mathematics" is nearly synonymous with the constructivist's definition of learning: Learning is the process by which human beings adapt to their experiential world. Learners construct knowledge of their world from their perceptions and experiences which are themselves mediated through their previous knowledge. The constructivist theory of learning is conducive to creating the kind of classroom envisioned and described by NCTM in the *Standards* (1989). This classroom is portrayed as a place where interesting problems are regularly explored using important mathematical ideas, with the premise that what a student learns depends to a great degree on how he or she has learned it (NCTM, 1989; p. 5).

Wood and Seller (1997) explained that the current efforts to change the ways in which mathematics is taught and learned in schools reflects a different view of reform, and the efforts to change mathematics education are unlike previous attempts at reform, saying:

> . . .the changes currently being proposed are derived from philosophical vision that can be considered epistemic in nature. This perspective advocates not only a change in the nature of mathematics taught in school, but also a different view of what it means to do mathematics—that is, a constructivist view of learning.
>
> From a psychological point of view, the contention is that students learn mathematics most effectively if they construct meanings for themselves, rather than simply being told. In support of this view, a great deal of evidence has shown that young children develop an intuitive and informal sense of mathematical concepts and procedures long before they enter school (Groen & Resnick, 1977; Hughes, 1981; Starkey & Gelman, 1982). . . . there is an increasing concern among mathematics educators regarding evidence that student's learning is restricted to rote procedures. As a consequence, many educators advocate creating situations in which students engage in reflective thinking and reasoning about mathematics (e.g., Kamii, 1994). It is also becoming increasingly clear that engaging students in reflective thinking influences not only their understanding but their motivation to learn as well (Pintrich, Marx, & Boyle, 1993; Skemp, 1976). (p. 164)

According to Wood & Sellers (1997) several theorists, such as Bauersfeld (1988) and Edwards and Mercer (1987) view the sociological perspective, the classroom environment, as an equally important influence on students' mathematical learning. The results of Wang, Haertel, and Walberg's 1993 study supported this theory, finding classroom environments that encouraged active student participation resulted in higher student achievement. The classroom environments that encouraged student participation were described as settings that involved extensive social interaction and engaged students in both metacognitive and cognitive processes (Wood & Sellers, 1997, p. 164).

In Henningsen & Stein's 1997 study of high-level mathematics thinking and reasoning they determined mathematical tasks are central to students' learning because "tasks convey messages about what mathematics and what doing mathematics entails" (NCTM, 1991, p. 24). Students learn to know the subject matter through the contexts of the tasks in which they engage while doing mathematics (Doyle, 1983, Marx & Walsh, 1988, Hiebert & Wearne, 1993). Henningsen, and Stein (1997) explain how tasks can influence the students' learning in the statement that follows:

> . . . the nature of tasks can potentially influence the structure the way students think and can serve to limit or to broaden their views of the subject

matter with which they are engaged. Students develop their sense of what it means to "do mathematics" from their actual experiences with mathematics, and their primary opportunities to experience mathematics as a discipline are seated in the classroom activities in which they engage (Schoenfeld, 1992, 1994). (p. 525)

Studies by Doyle in 1983, 1986, and 1988 showed that high-level tasks were often complex and longer in duration than more routine classroom activities and, therefore, were more susceptible to various factors that could cause a decline in students' engagement to less demanding thought processes (Henningsen & Stein, 1977). Results of a1996 study by Stein, Grover and Henningsen about tasks in middle school reform mathematics classrooms indicated that teachers had difficulty maintaining high levels of student cognitive processing throughout task implementation. These factors suggest that attention should be given to the classroom processes surrounding mathematical task as well as to the nature of the task.

Henningsen and Stein (1997) found the following factors influential in assisting students to engage at high levels of activity and thinking:

> These include factors related to the appropriateness of the task for the students and to supportive actions by teachers, such as scaffolding and consistently pressing students to provide meaningful explanations or make meaningful connections. These findings have implications for the role of the teacher in reform classrooms, in which students are expected to be actively engaged in doing mathematics. Not only must the teacher select and appropriately set up worthwhile mathematics tasks, but the teacher must also proactively and consistently support students' cognitive activity without reducing the complexity and cognitive demands of the task. (p. 546)

The NCTM *Standards* (1989) encourage teachers to foster communication by using small- and whole-group discussions in mathematics by asking questions or posing problem situations that actively engage students and to encourage them to refine their growing abilities to communicate mathematical thought processes and strategies (p. 78). A change in the type of discourse used in the classroom is a key component to reforming instruction. Cobb, McClain, & Whitenack (1997) described the importance of discourse in reform in the statement that follows:

> The current reform movement in mathematics places considerable emphasis on the role that classroom discourse can play in supporting students' conceptual development. The consensus on this point transcends theoretical difference and includes researchers who draw primarily on mathematics as a

discipline (Lampert, 1990), on constructivist theory and on sociocultural theory (Forman, 1996; van Oers, 1996).

Leikin & Zaslavsky (1997) found in their research on mathematical communication in small groups that small-group cooperative learning promoted students' activeness and that small-group cooperative learning facilitated a higher level of learning activities. They found that cooperative learning provided opportunities for students to engage in constructing explanations regarding underlying principles for solving mathematics problems. An increase in students' interactions in general, and in their mathematical communications in particular, had a positive effect on learning (p. 351-352).

In their article "Creating Constructivist Environments and Constructing Creative Mathematics," Susan Pirie and Thomas Kieren (1992) discussed how a constructivist learning environment is developed by a teacher, and they described what teaching based on a constructivist philosophy looks like. The information shared supports and enhances the recommendations and suggestions made by the NCTM *Standards* for improving mathematics learning and teaching, and provides guidance for the analysis procedures of classroom observation data. Pirie and Kieren (1992) offered four tenets of belief as critical for teachers who desire to create a constructivist learning environment. These beliefs are summarized below:

1) Although a teacher may have the intention to move students towards particular mathematics learning goals, he or she will be well aware that such progress may not be achieved by some of the students and may not be achieved as expected by others. Students will build their own knowledge and mathematical understanding, and it may not always be compatible to the mathematical understanding of the teacher, or to the teacher's expectations and goals. The teacher will continually be re-creating the learning environment based on the individual student's understanding and on the class as a whole. The teacher cannot have the intention of planning a teaching sequence and expect to simply apply that plan. The teacher must constantly reappraise the learning taking place within the classroom environment as it evolves.

2) In creating an environment or providing opportunities for children to modify their mathematical understanding, the teacher will act upon the belief that there are different pathways to similar mathematical understanding. This belief, in different routes to mathematical understanding, entails a realization that each student comes to his or her current state of understanding through

a unique pattern of engagement in the various kinds of activities offered. There is no unique or even best path for growth in understanding. As a direct consequence of this there is also no particular form, or sequence, of instruction which can be positively associated with growth in understanding in a constructivist environment.

3) The teacher will be aware that different people will hold different mathematical understandings. A number of implications follow. The teacher cannot think that his or her own understanding, the understanding of a given mathematician, the understanding underlying the writing of particular texts and materials, and the students' understanding will all be the same for any particular mathematical topic. Thus, the teacher will be oriented to account for this variation. This inter-students difference is not simply a matter of rate or style in reaching a given understanding of a topic. There is no such thing as, for example, an understanding of fractions to eventually be passed on to, or even gained by students. An understanding of a topic is not an acquisition. Understanding is an ongoing process which is by nature unique to that student. Holding this tenet implies that the teacher believes in and, just as importantly, acts on this difference in understanding.

4) The teacher will understand that for any given topic there are different levels of understanding, and that these are never achieved 'once and for all.' Concern for, and allowing for, the growth of the mathematical student must be the teachers' intentions. Mathematical understanding entails the continual organization of self-built knowledge structures which is an ongoing, dynamic process. It is essential that the teacher understands this process which consists of eight levels that are not necessarily linear: primitive knowing, image making, image having, property noticing, formalizing, observing, structuring, and inventing. The implications for the teacher concerns how she or he reacts to what he or she observes in the classroom. Not only will he or she be aware that students will come to understanding in different ways, but will also expect that different students will exhibit different kinds of understanding in the face of the same mathematical task. It is possible that two students may appear to exhibit the same understanding but this may not be the case. Simply examining what the student does to solve a mathematical task is not enough. The teacher must prompt students

> to reveal their thinking and logic by having them justify what they say or do. In order to expose different levels of understanding, tasks need to be used which allow for varying levels of response. (Pirie and Kieren, 1992, pp. 508-9)

Bauersfeld's (1992) study based on radical constructivism, combined with what he describes as compatible elaboration of the role of the social dimension in individual process supports these constructivist teaching and learning strategies. The results of the study point to findings that show significant advantages for the learner. Bauersfeld (1992) claims the use of constructivism can help individuals break out of their sense driven mode of continual, strongly felt, need to adapt one's own actions to the social practice in the mathematics classroom. This can generate flexibility in "mathematizing" any subject matter, plus this flexibility is required for problem solving. Following is a summary of some of his specific findings (p. 468).

Using a constructivist approach forces teachers to focus on the understanding of the students rather than on training them in a particular procedure. The well prepared teacher can generate intensive discussions of subject matter which related to issues being taught. This opens up opportunities to develop the "language game" of reflection which is essential in knitting concepts together. Creating learning situations that involve "underdetermined tasks" require group discussions to determine, or to clear up, the individual's understandings, and this requires students to negotiate the methods and strategies of their solutions. (Bauersfeld, 1992, pp. 472-475)

Process versus product orientation allows the teacher to gain insight as to whether the student understands how to solve a problem or simply knows the procedure for getting the correct solution. An added twist to this scenario is that when teachers fill in the procedural knowledge gaps for students, which they often do, students can conceal their lack of understanding by acting as if the gap was simply a minor error, or slip up. . . . Having students explain their thought processes and justify answers helps eliminate this problem (Bauersfeld, 1992).

Simon (1993), suggests that teachers have a dual role of fostering the development of conceptual knowledge of students while facilitating the constitution of shared knowledge in the classroom community. Cobb, Wood, and Yackel's study (1994; as cited in Simon 1993) demonstrated that mathematics conversations in the classroom that were facilitated by the teacher resulted in taken-as-shared mathematical knowledge. *The Professional Standards for School Mathematics* (NCTM, 1991) is supportive of these perspectives with the four key areas of responsibility for teachers that are described as follows:

- Setting goals and selecting or creating mathematical tasks to help students achieve these goals;
- Stimulating and managing classroom discourse so that both the students and teacher are clear about what is being learned;
- Creating a classroom environment to support teaching and learning mathematics;
- Analyzing student learning, the mathematical task, and the environment in order to make ongoing instructional decisions. (p. 5)

Summary

Both the review of the research and literature support that mathematics reforms recommended by the NCTM three volume set of *Standards*, are grounded in the constructivist theory of learning and, although there are a variety of constructivist's beliefs, the constructivist based reform promote changes in mathematics classrooms to student-centered classrooms where students are actively engaged in problem solving and mathematical communication to construct understandings of mathematical concepts. Teachers are expected to facilitate students' progress in making connections between procedural knowledge and conceptual understanding and to make connections between mathematics and their world. Worthwhile challenging tasks are suggested in place of drill-and-rote practice, and teachers are encouraged to use both small-group and whole-group discussions in the classroom. Teachers should no longer be dispensing knowledge in small unconnected chunks but should be involving students in problem-solving inquiry that builds understanding of numbers and number sense.

The research provides guideline for documenting reform of classrooms mathematics education. Evidence of reform will be provided if the following changes are observed in classrooms: (1) higher-level tasks are used in the classroom instead of drill-and-rote practice, (2) tasks are worthwhile and appropriate, (3) discourse in the classroom changes, less teacher talk and more student talk, (4) the classroom environment encourages student communication rather than passiveness, (5) a variety of methods of communication are used for students to explain or demonstrate their understanding, and (6) teachers provide opportunities for students to participate in reflective thought.

Chapter III
Methodology and Analysis Procedures

The first three sections of this chapter provide details concerning why a case study approach was selected for documenting system reform, how the case study was designed, and how the data collection was organized and implemented. Three specific goals for these three sections of the chapter are to: (1) present the rationale for selecting a case study approach to document systemic reform, (2) provide an overview of the case study's organizational structure, and (3) provide details concerning data collection for each of the three levels of the study. Analysis procedures for Level I, Level II and Level III of the study are presented independently; therefore, the three sections that follow data collection information are devoted to explaining the procedures used to analyze the data collected from each level of the investigation. Information provided in the analysis procedures for each level of the study include: (1) the rationale and justifications for, and the development of, the coding scheme used for data analysis, and (2) procedures for, and the structure of, the subsequent analysis of each level's coded data. This chapter concludes with an explanation of how the analyzed data from the three different levels of the study document systemic reform.

Research Design: Rationale

This research consisted of an in-depth case study of one middle school engaged in mathematics systemic reform. As presented in the history of educational reform, systemic reform is an innovative approach that has only recently been put into practice. This fact, combined with the complexity of systemic reform, motivated a research approach which was both holistic and ethnographic. According to Jacob (1987) research designed in holistic ethnography is an exploration into the unknown, and, consequently, there is no standard research design. ". . .the research design evolves as the work progresses with a cross-fertilization of analysis and observation." (Malinowski, 1922/1961, p.13, as cited in Jacob, 1987, p. 14)

Even though a holistic approach was adopted for this case study, the parameters of the study did narrow the focus to viewing systemic reform through the lens of V-QUEST's Systemic Indicators and to documenting systemic reform for one middle school for one subject— mathematics. The need for on going analysis during data collection resulted in the use of descriptive and interpretive research methods to complete the case study's design. Descriptive research describes and interprets what is (Cohen, 1994, p. 67); a descriptive case study provides detailed accounts of the phenomena under study, and it is not motivated by the need to formulate general hypotheses. Interpretive case studies contain rich descriptions which are used to support or challenge theoretical assumptions held prior to the data gathering (Merriamm, 1988, as cited in Clarke, 1993). The assumption for this case study is that involvement in the V-QUEST Systemic Reform movement resulted in mathematics education reform in one particular middle school.

In an article about criteria for taking an ethnographic approach to studies of educational topics, Wolcott (1975) listed examples of educational topics appropriate for ethnographic research. Following are some of the suggested topics: school environment, material culture/technology, personal adaptations in both words and action, and cultural stability and change (Wolcott, 1975). All of these topics fall under the umbrella of this research project. In 1976-77 Robert Stake was funded by NSF to conduct studies of the status of precollege science education. His multiple science classroom research proposal was based on a case study approach (Stake, 1978). The explanation of the conceptual frame work of Stake's study begins with the following proposition:

> Seeing rather than measuring was the activity of this project. "Issues" were central foci, guiding the seeing, organizing the understanding. . . . What principally we hoped to see was "how much science is being taught (and) the obstacles to good science teaching." (Stake, 1978, p. c:1)

Since documenting systemic reform was the ultimate goal of this study, identifying mathematics educational reform and providing a snapshot view of the 1995-96 mathematics educational practice were two of the major goals of this study. Issues that guided "the seeing" with regards to the status of mathematics education were NCTM's three sets of *Standards* publications (hereinafter referred to as *Standards*): *Curriculum and Evaluation Standards for Teaching Mathematics* (*Curriculum Standards*), *Professional Standards for Teaching mathematics* (*Professional Standards*), and *Assessment Standards for School Mathematics* (*Assessment Standards*). These documents were used in conjunction with V-QUEST's indicators of systemic reform to document systemic reform in mathematics education in one middle school. The organizational structure designed and used for this case study is presented in the next section.

Organizational Structure of the Study

With only minor adaptations, the conceptual framework used by Stake in his 1976-77 status of science education case study provided the organizational structure used for documenting systemic reform in the this study. The model of this organizational structure presented in Figure 1 shows the various connections between the three levels explained in this overview of the study's design. An explanation of how the analysis and data collection worked together to direct the design of the study is included.

As illustrated on the next page in Figure 1, three interrelated levels best describe the chronological structure of this study. Level I focused on the status of mathematics education in the 1995-96 school year. The question that guided that part of the study was: “To what extent was there agreement between current mathematics educational practice and NCTM’s recommended goals for mathematics reform?” Classroom observations, interviews with a variety of members of the school population, and analysis of related artifacts were used to create a snapshot view of mathematics education at one middle school. Using the lens of NCTM’s recommendations for reform in mathematics education, an interpretive analysis of the data was used to determine the extent to which mathematics instructional practices observed matched the NCTM goals for reform in mathematics instruction. The results of this initial investigation provided the direction for Level II of the investigation.

Level II of the study focused on instructional practices that matched the NCTM reform recommendations. The question that guided this part of the investigation was: “To what extent had the match between the NCTM *Standards* and this middle school’s mathematics program changed since involvement with V-QUEST? Baseline data for the school year prior to involvement with V-QUEST consisted of interviews with a variety of members of the school’s population and artifacts from the 1992-93 and subsequent school years. Triangulation of these data was used to establish the status of mathematics education during the 1992-93 school by focusing on any NCTM reform goals that were in mathematics educational practiced at that time.

At this level of the investigation data related to the interim school years of 1993-94 and 1994-95 were also collected and analyzed. The purpose of this part of the research was to track any reform goals that were identified in Level I of the study and to identify and track any reform initiatives for change that were not sustained. Data collection for this part of Level II relied on interviews and artifacts which paralleled those previously described for establishing baseline data.

Documenting and tracking reform goals was dependent on triangulation of data collected through interviews and artifacts. An interpretive analysis based on the comparison of the baseline data to data of the interim and current years was used to document patterns of change. Any documented changes in mathematics education from Level II of the study became the central focus of investigation for Level III. The guiding question for Level III of the study was: “To what extent was the documented change evidence of systemic change?” Research methods for Level III consisted of a comparative analysis between documented changes and a selected subset of systemic indicators developed by V-QUEST’s Steering Committee. The purpose of this comparative analysis was to determine the extent to which there was a match and therefore document the extent to which systemic reform had occurred.

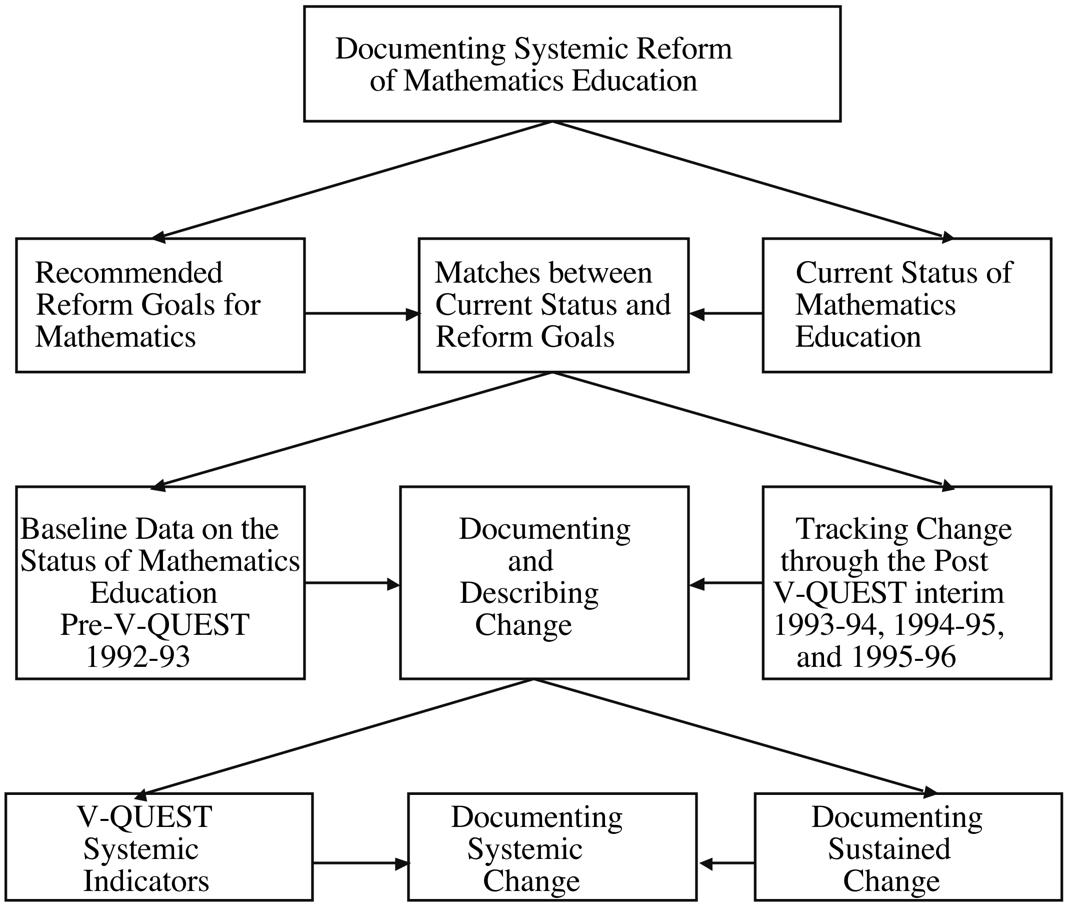

Figure 1. Organizational Model of the Case Study.

Data Collection

Provided in this section are detailed descriptions of data collection procedures and methods used for each of the three levels of this study. Descriptions of data collection for each level include the research question specific to each level of the study, method of participant selection, methods of data collection, procedures for data collection, a brief explanation of how on-going interpretive analysis directed data collection, and details concerning the data collection instruments.

Methods of data collection included classroom observations, interviews artifacts. Explanations of how each data source specifically contributed to Levels I, II, and III of the research are presented with each level's information, but procedures used with each particular method are presented in only one section. Details concerning data collection via classroom observations and teacher interviews are presented in Level I. Data collection methods for Level II focus on the investigation of artifacts and interviews of other staff members within the building and at the county level. Level III information explains how interviews with state-level education administrators and affiliates were used to collect data to complete the research for documenting systemic reform.

Level I: Data Collection Methods and Procedures.

Level I was designed to collect data pertaining to the status of mathematics instruction in classrooms during the 1995-96 school year. The research question that guided data collection for this level of the study was: "To what extent does the mathematics instruction implemented in the classrooms match the NCTM's recommended educational reforms?" The primary sources for this information were the sixth, seventh and eighth grade mathematics classes at the middle school; thus, selecting the participants for classroom observations and setting parameters for the classroom observations were the first research tasks addressed.

Permission to conduct this study at Pleasant Middle School depended on the cooperation of the mathematics teachers at the school; therefore, the initial invitation to participate in the research project was extended to the faculty and staff by the school's principal. After the proposal was favorably received the researcher was granted permission by the principal to personally contact potential research participants. Selection of seventh and eighth grade mathematics teachers for the study was simplified by the fact that there were only two of each and all four agreed to participate in the study. An invitation was extended to all six of the sixth grade teachers that taught mathematics but only two out of six agreed to participate in the study. Reasons for declining to participate varied; one teacher explained that this was her first year teaching mathematics and that she did not feel comfortable with the idea of being observed, but most declined saying that they did not have time or that they simply were not interested in participating. Both of the sixth grade teachers that agreed to participate expressed an interest in mathematics reform and wanted to help in any way they could. This set of participants fulfilled the desired quota for data collection of two teachers from each grade level represented at the school.

The brief profiles of these participants (see Appendix A) provide the following pertinent factual information about the teachers: sex, race, number of years teaching experience, number of years teaching mathematics, number of years teaching mathematics at this grade level, number of years teaching in this school, and professional memberships. In addition to this demographic information this section also provides details concerning methods used for selection of specific mathematics classes for observation, the type of mathematics classes observed (algebra, pre-algebra, general mathematics), class size and composition (heterogeneously or homogeneously grouped), common instructional materials used at each grade level, curriculum guidelines and scheduling specifications.

<u>Level I: Meeting the Participants and Selection of Classes for Observations</u>

Pleasant Middle School was built in 1948 long and was designed with three wings that had multiple levels connected by winding hallways that went up and down short and long flights of stairs. The school was organized by grade levels and teams with the sixth grade two-person teams or self-contained classrooms occupying the front hallways on the first and second floors, the eighth grade four-person teams located on the first and second floors of one wing, and the seventh grade four-person teams in the same arrangement in the other wing. Common areas shared by all grade levels were the cafeteria, library, computer lab, auditorium, all exploratory-classes facilities, and guidance and administrative services. As a result of the school's participation in a Channel One Programming contract each classroom was equipped with a television, and the school was wired for close circuit television service.

Introductions of individual teacher participants begins with the eighth grade mathematics teachers: Mr. A, the V-QUEST Lead Teacher representative, and Mrs. D. Both teachers had over twenty years experience teaching eighth grade mathematics at this middle school, and both teachers were members of NCTM, NEA and VEA. Mr. A's room was on the lower level of the second floor and Mrs. D's room was right underneath on the lower level of the first floor; both had three other academic team members (i.e., Language Arts, Social Studies, and Science) located in the surrounding classrooms. Both eighth grade teachers used the county curriculum guidelines which were based on the 1988 *Standards of Learning Objectives for Virginia Public Schools*. They both used the *Merrill Pre-Algebra* and the *Glencoe Algebra* textbooks, and they regularly shared instructional strategies and supplemental materials.

Since every eighth grade student in Pleasant Middle School was scheduled to take either algebra or pre-algebra, the students who did not qualify for algebra were automatically placed in a pre-algebra class; thus, the eighth grade classes were somewhat homogeneously grouped. Both teachers taught eighth grade algebra and pre-algebra and followed a block schedule; it had three ninety-minute classes each day and a ninety-minute planning time which was the first block of the day. The common practice for Mr. A and Mrs. D, as well as the rest of the eighth grade teachers, was to meet in the cafeteria and spend their planning time working together. There was a cooperative and supportive working relationship between the two eighth grade mathematics teachers and their team members; thus, both of the teachers were involved in the selection process for determining which of their three mathematics classes would participate in the study.

Since both eighth grade mathematics teachers agreed that they used more hands-on instruction with their pre-algebra classes than their algebra classes, it was decided that the pre-algebra classes would be the best candidates for participation in the study. Mr. A's observations were scheduled first, and he selected his third block pre-algebra class which met each day just before lunch from 11:45 to 1:05 and consisted of twelve boys and ten girls. Although it was not her first choice, Mrs. D permitted her fourth block pre-algebra class to participate in the study. This was not her best class of the day for at least three reasons: (1) it was the last block of the day, (2) it consisted of sixteen boys and four girls, and (3) homogeneous grouping placed twenty fairly unmotivated and low ability students together in this class. To conserve the researcher's time by scheduling two observations in the same school day, Mrs. D agreed to let this class participate in the study.

Much like the eighth grade mathematics teachers, both of the seventh grade teachers were members of four-person academic teams, and they followed the same block schedule; this provided them a common planning time second block each day. They both followed the same county curriculum guidelines based on the 1988 *Standards of Learning Objectives for Virginia Public Schools*, and they both used the same *Glencoe Course 2* textbook. Like the eighth grade teachers, they shared instructional strategy ideas and supplemental materials with each other during their common planning time. Since the seventh grade students were not grouped for algebra and pre-algebra, both seventh grade teachers taught heterogeneously grouped classes. Any seventh or sixth grade student who was ready for algebra or pre-algebra was scheduled into one of the eighth grade classes, but there were only a few of those students, so for the most part the mathematics classes taught by the seventh grade teachers were similar in size and ability mix.

Unlike the eighth grade mathematics teachers, both seventh grade teachers had experience teaching other subjects and other grade levels. Mrs. N had a total of twenty-four years teaching experience at the middle school level, but the first fourteen years of her career were spent teaching all subjects including mathematics at the sixth grade level. At her request the last ten years of her career had been devoted to teaching seventh grade mathematics. Ms. L proved to be the new kid on the block with only seven years teaching experience at the middle level, and this was her first year teaching math; previously she had taught science, health or physical education. Neither of the seventh grade teachers were members of t NCTM, but Ms. N did belong to PCEA, VEA and NEA.

Both of the seventh grade teachers were involved in the process for selecting which of their mathematics classes would participate in the study, but unlike the eighth grade teachers they worked independently to make their decisions. Both teachers indicated they wanted their best classes to participate in the study, and both identified their first block classes which met from 8:45 to 10:09 daily. Since the eighth and sixth grade classroom observations were scheduled to conserve as much research time as possible, it was possible to honor the seventh grade teachers' request and schedule their observations independently. Ms. L's first block class had 25 students consisting of 12 girls and 13 boys, and Ms. N's class contained 26 students, 11 girls and 15 boys.

The sixth grade teachers did not use the same block schedule as the seventh and eighth grade teachers, and the teachers worked on two-person teams instead of four-person teams. Two sixth grade teachers shared the responsibility for teaching about fifty sixth-grade students, and they each taught two subjects. Mrs. W and Mr. M taught on two different teams, and both had the responsibility of teaching mathematics and social studies for their teams. Their second team members taught science and language arts, and, since the sixth grade students had a full year of science and social studies, their mathematics block was only forty-five to fifty-five minutes each day. The mathematics and social studies teachers had the option of dividing their two hour block of instructional time between social studies and mathematics as they saw fit, and on some days more time was spent on mathematics than social studies and vice-versa. The typical mathematics class lasted fifty-five minutes.

Just as with the seventh and eighth grade teachers, both sixth grade mathematics teachers followed the county curriculum guidelines that were based on the 1988 *Standards of Learning Objectives for Virginia Public Schools*. Although the sixth grade teachers had a common planning time from 1:30 to 3:05 daily, they did not share ideas or plans across teams. Both teachers had access to the same instructional materials including the Glencoe *Course 1* textbook and supplemental materials. Like the seventh grade mathematics classes, the students were not grouped by ability; therefore, both sixth grade mathematics teachers taught heterogeneously grouped classes. Also, like the seventh grade teachers both sixth grade teachers were members of the PCEA, VEA and NEA, and neither were members of the NCTM. Mr. M was a member of both the National and Virginia Middle School Associations.

Ms. W had taught for twenty-two years, and the last nineteen were spent teaching sixth grade. When asked if she had always taught mathematics she answered "Well, yes. I guess you could say I've always taught math during one period of the day. There were two years that I only taught math and reading. . . .This year I am teaching social studies and math. I think science and math go together better." She had no objections to teaching mathematics, but she didn't care much for teaching reading. Mr. M had been teaching for twenty-three years, and all but two of those years had been spent teaching sixth grade. He taught third grade for two years, but when Pleasant Middle School became a middle school Mr. M joined the teaching staff as a sixth grade teacher.

Like the seventh and eighth grade teachers both of the sixth grade teachers were involved in selecting which of their two classes would participate in the study. Ms. W indicated that her first mathematics class of the day would be the best for participation in the study. This class had 23 students, 10 girls and 13 boys, and it met from approximately 9:50 to 10:45 daily. She did not always use the same schedule; sometimes she taught social studies before she taught mathematics, and she varied the amount of time spent on each subject. Mr. M was open to having either of his classes participate in the study, and, to accommodate the researcher in scheduling two classroom observations in one school day, he agreed to let his second class participate. Like Ms. W the amount of time Mr. M spent teaching mathematics varied by five to ten minutes each day depending on what was planned for the two hour block. This class started at 11:30, and it consisted of 24 students, 11 girls and 13 boys. A summary of the pertinent information for each teacher involved in the study is provided in Appendix A, Table A, and the schedule for the classroom observations and teacher interviews is provided in Appendix B, Table B. The next section explains the data collection methods and procedures used for Level I of the study.

<u>Level I: Data Collection Methods and Procedures for Classroom Observations</u>

Data collection for classroom observations consisted of transcribed audio recordings, artifacts, an observation summary/checklist (see Appendix C), and field notes taken over one three-day and one two-day observational periods. To eliminate the possibility that the teaching methods observed during the first three-day observational period were limited to those appropriate to a single topic it was necessary to allow enough time between the first and second observations for the teacher to change units or mathematical objectives. For this reason the second two-day observation period was scheduled at least two weeks after the first. The three-day classroom observations began with the eighth-grade teachers, Mr. A and Mrs. D on March 4, 1996. Three-day observations for the seventh-grade teachers were completed between March 11th and March 20th and ended with the sixth-grade teachers on April 11, 1996. Follow-up interviews were scheduled between April 2nd and May 26th, and the follow-up two-day observational periods were conducted from April 15th to May 8th. A schedule of these events is provided in Appendix B, Table B.

Data collection for classroom observations focused on the physical classroom and the teacher, and a specific set of criteria based on recommendations from the NCTM *Standards* publications was used to guide data collection. To determine the status of mathematics education in the 1995-96 school year the *Curriculum and Professional Standards* identified four significant categories of instruction: task, discourse, environment and analysis. A rationale for selection of these categories and specific details of their indicators are presented in the procedures for analysis of Level I section of this chapter and in Tables L1, L2, L3 and L4 (see Appendix L).

An observation summary/checklist (see Appendix C) was created to insure that similar data were collected from each classroom observation and to facilitate the on-going analysis necessary for creating subsequent interview instruments for Levels II and III of the study. This observation summary/checklist was adapted from the one Robert Stake (1978) used in his NSF-funded study of the status of science education. In his study multiple researchers were involved in the data collection process, and an observation summary/check list that focused on pertinent science instructional strategies was used to standardize data collection.

Using suggestions from the NCTM *Standards* this observation summary/checklist was modified to focus on mathematics education; it was used as a data collection instrument for each classroom observation. The observation summary/checklist was also used to facilitate development of the interview instruments used in Level II of the study. Details concerning data collection for Level II are presented in the next section.

Level II: Data Collection Methods and Procedures

The goal of Level II of the study was to document any changes in educational practices in the classroom since involvement with the V-QUEST Lead Teacher Program. To do this it was necessary to establish two sets of data: (1) baseline data for any classroom practices that proved to be supportive of reform recommendations, and (2) data for tracking any reform initiatives through the interim years. The classroom observations, related interviews, and the investigation of pertinent artifacts provided data to verify the mathematics teachers' involvement or lack of involvement in implementing educational reform in the teaching and learning of mathematics in their classrooms. An on going analysis of the data collected was essential for moving from one level of the study to the next, but for the sake of clarity specific details concerning the analysis procedures used will be presented after the methods of data collection. Methods of data collection used for Level II were: (1) interviews with the observed mathematics teachers, (2) interviews with other school staff members, (3) interviews with county level administrators, and (4) artifacts.

The observation summary/checklist was used to analyze data collected from the first of the two classroom observation cycles. This initial analysis resulted in comparative summaries of each observation, and these summaries were used to formulate questions for major interviews which where conducted with each mathematics teacher observed, school support staff and each administrator. Research questions were constructed for each observed mathematics teacher to provide data for evidence of effective mathematics teaching and learning consistent with the goals of the V-QUEST Lead Teacher program in any or all of the following areas related to mathematics educational reform: (1) knowledge of the recommended educational reform in mathematics curriculum and mathematics materials, (2) pedagogy including methods of teaching and philosophy of teaching, integration of mathematics with other content areas especially science, the use of technology, and the classroom environment, and (3) knowledge of alternative forms of assessment.

All interviews were semistructured and openended and were designed to collect data from the individual teachers, school support staff and administrators concerning their views, beliefs, and knowledge of recommended mathematics education reforms. Although the interviews were openended, the sequence and overall design of the interviews was structured. The teacher interviews were designed to meet two goals: (1) to provide details related to the classroom observation that would facilitate the creation of a snapshot view of the current (1995-96) status of mathematics education, and (2) to probe any areas in which mathematics instruction had changed over the last five years. The interviews were organized into two areas, demographics and questions related to the classroom observation. Questions about the classroom observation ranged from specific inquiries about instructional practices observed to related questions about what happened before and after the observed lesson.

During the semi-structured interviews each teacher was shown a five-by-eight index card that listed six particular areas of interest for the study (mathematics content, materials needed, assessment, connections, communication and students' needs) and each teachers was encouraged to focus his or her responses on these areas of instruction as appropriate. The teacher interview instrument is presented in Appendix D.

All the major interviews were about one hour; each was recorded and transcribed. All the major teacher interviews were conducted after the first three day observation period and before the interviews with other members of the school population (see Appendix B, Table B). All teachers opted to complete the interview at school in their own classrooms during their planning times. Schedules were tight, and time was precious, so interview questions and their follow up probes were carefully planned and organized prior to each interview.

An interpretative analysis of this first cycle of interviews was used to determine which other members of the school population and division-level administrators should be interviewed and to create the interview instruments for those participants. In addition to the six mathematics teachers, six other members of the school population were requested to participate in the study, and all six of them participated cooperatively (current principal, past principal, librarian, mathematics and science V-QUEST Lead Teachers, and a language arts teacher from the mathematics lead teacher's eighth grade instructional team). At the division level interviews were conducted with six administrators: the Supervisor of Technology Instruction, the K-8 Gifted and Talented Resource Teacher, the administrative contact for the V-QUEST Lead Teacher Program, the Associate Superintendent, the Coordinator of Elementary and Middle School Instructional Programs, and the Superintendent.

As with the teacher interview instruments, the interviews for the other members of the school and division level administrators were also semistructured instruments that provided evidence of change in mathematics instruction over the past five years and evidence for tracking identified reform efforts. Before each interview each participant was asked to focus his/her responses on the middle school involved in the study and, specifically, on mathematics instruction and the V-QUEST Systemic Reform Initiative.

All of the interviews were recorded and transcribed for an interpretative analysis which compared baseline data to the tracked reforms; the goal was to document local mathematics reform efforts. Three of these interviews, both V-QUEST Lead Teachers and the K-8 Gifted and Talented Resource Teacher, were conducted after school at local restaurants. The other administrative interviews were conducted in participants' offices during work hours, and the other teachers or members of the school population opted to be interviewed in their classrooms during their planning time. The interviews conducted with the six other members of the school's population are presented in Appendix E, and the interview conducted with division level administrators is presented in Appendix F. These twelve interviews started with the school's principal, Mr. G, on May 20, 1996, and concluded with a second interview of the V-QUEST lead math teacher, Mr. A, on July 22, 1996. A schedule for the six interviews with other members of the school population is provided in Appendix G, Table G1, and Table G2 provides the schedule for the six division level administrators' interviews.

Level II: Data Collection and Artifacts

Artifacts were collected whenever possible to document change and triangulate data collected from interviews with teachers, school support staff, and administrators. Following is a list of artifacts:

(1) **Scrapbooks** of events for each school year were available from the school library. (This part of the investigation focused on guest speakers in mathematics classes, field trips related to mathematics, projects or functions that involved the collaboration of the

school and local businesses and any mathematics related contests or special events, and so on.)

(2) **County and school documents** that indicated the number and types of in-service or teacher training provided.

(3) Mathematics teachers' **lesson plans**.

(4) **School-wide inventory of mathematics teaching materials** available for each of the five years covered by this study.

(5) **Records** which reveal uses of the county's **Eisenhower Funds**.

(6) **Records** concerning **professional leave** for faculty and staff members to attend state and /or national conferences.

(7) **Records** to document the availability of **professional magazines**, **and memberships** in professional organizations such as the NCTM.

(8) **Samples** of mathematics teachers' **assessments** from the 1992-3 school year to the 1996-97 school year.

(9) Classroom **inventory** lists from teachers in the study to indicate the nature and quantity of **technological** equipment available and also to determine the types of instructional materials on-hand.

(10) Copies of any **handouts** used by the teachers for instructional purposes.

(11) Copies of the **1988 SOLs** and copies of the drafts of the **new 1995 SOLs**.

(12) Copies of the **county's curriculum guide** and copies of drafts of **updates.**

Data from these artifacts were triangulated with data from the major interviews and classroom observations to establish baselines and document reform. Analysis of these data also generated questions that were included in the major interviews conducted in Level II and Level III of the investigation. Details of the procedures for the interpretive analysis used to document any sustained reforms and/or changes consistent with the NCTM *Standards* are provided in the portion of this chapter devoted to procedures for analysis of Level II. These data combined with data collected in Level III from state-level educational personnel and affiliates were correlated with a selected subset of V-QUEST indicators of systemic reform to complete the documentation of systemic reform in Pleasant Middle School. The data collection procedures for Level III of the study are presented in the next section.

Level III: Data Collection Methods and Procedures

Since this is a case study to document systemic reform in mathematics education at one middle school, the concept of systemic reform required that information pertaining to educational mandates, policies and programs that originated at the division and state levels be investigated. The interviews for division and state levels were designed to collect information concerning those mandates, policies and programs that were surmised to have a direct link to instructional practices used in classrooms and to the systemic indicators used to identify and document systemic reform. The main links between state and local education were curriculum, assessment, instructional materials, and technical assistance.

A significant feature of systemic reform was described in a 1991 *Policy Brief* for the Consortium for Policy Research in Education (CPRE) as a systemic state structure that supports school-site efforts to improve classroom instruction. This structure should be based on clear and challenging Standards for student learning with policy components that are tied to the Standards and that reinforce one another in providing guidance to schools and teachers about instruction (Smith and O'Day, 1991 as cited in CPRE Policy Brief 1991). The purpose of the state-level interviews was to gather information to document whether this crucial component of systemic reform was indeed in place and functioning in this county.

The specific interview questions were based on four pieces of information: (1) analysis of data collected from teacher interviews, (2) analysis of data collected from interviews with other members of the school's personnel, (3) analysis of data collected from county level interviews, and (4) applicable systemic indicators. For each of the four areas that revealed a direct link between practice in the classroom and state-level of education, questions were constructed to determine if the points of interest were intended to support instructional reform in the classroom, if teachers were involved in the processes of decision making, if the concepts were compatible with desired outcomes of the V-QUEST's Lead Teacher Program and the NCTM *Standards,* if there was any room for flexibility in decision making at the local level, how instructional reform was supported, and exactly what changes occurred.

A description of the specific points that created the links between local and state-level education follows for each of the four areas: curriculum, assessment, instructional materials, and technical assistance. The state's newly revised *Standards of Learning(SOL) for Mathematics* served as the point for curriculum related questions. Accompanying the new *SOL*s were the state's new testing and assessment mandates. These mandates were the centerpiece for questions relating to assessment. Instructional materials was one of V-QUEST's seven components and, in conjunction with a mini-consortium of states, a standard set of criteria, indicators and processes for evaluating instructional materials and resources was constructed. This document was the basis for most of the questions about instructional materials. The questions about technical assistance were designed around these mandates and policies and sought to determine exactly what the state had done to support teachers in the implementation of these changes into the classroom—V-QUEST, of course, was one of those initiatives.

State and non-division level personnel who were directly involved in V-QUEST and/or any of the above mentioned areas were selected as candidates for participation in data collection for Level III of this study. Following is a list of the six participants interviewed: (1) Director of the Administrative Component of V-QUEST and the former Coordinator for Special Programs in the county, (2) State Department Principal Specialist of Assessment and Director of the Assessment Component of V-QUEST, (3) Mathematics Coordinator for Fairfax County Public Schools and the leader for the development of Virginia's new SOLs, (4) Associate Specialist of Instructional Media and Training who was also a member of the textbook consortium committee responsible for writing the criterion referenced instrument for adoption of instructional materials, (5) one of the training team leaders for Virginia's southwest region of fifteen school divisions who also served as a member of the committee responsible for developing the middle school mathematics *Standards of Learning*, (6) State Department Principal Specialist for Mathematics, and one of the original writers of the V-QUEST proposal and the liaison from the State Department of Education to the *Standards of Learning* development committee.

Each interview was about one hour, and each participant was asked to focus his/her responses on middle school mathematics as much as possible. All interviews were recorded and transcribed, and all but two of the interviews (the director of the Administrative Component of V-QUEST and the Training Team Leader) were conducted over the telephone. Each of the participants received a copy of the questions at least a week in advance of the scheduled interview . The interviews were structured, but the questions were opened ended and always followed up with "Is there anything else you would like to add?" which permitted participants to provide information that may not have been solicited by the researcher. The non-instructional staff state-level interview is provided in Appendix H, and a schedule of interviews is provided in Appendix I, Table I. Procedures for analysis for this and the other two levels of the study follow in the next section.

Level I Analysis Procedures

"What is taught" and "how it is taught" shared the focus of the coding system designed for analysis of the mathematics classroom observation and interview data. The two-fold purpose of this coding system was to: (a) provide data which could be used to make comparisons and generalizations about mathematics instruction across three observed grade levels, and (b) provide data to determine to what extent the mathematics instruction at Pleasant Middle School match the NCTM *Standards'* recommendations. The structure of the coding system pertaining to **what** was taught was based on the NCTM *Curriculum*

Standards, and the foundation for analysis of **how** it was taught was based on the NCTM *Professional Standards*.

The NCTM *Curriculum Standards* Used in this Study

The first four Standards of the NCTM *Curriculum Standards* were used as the bases for analyzing what was taught because these four Standards are the same for all grade levels, K-12, and they cut across all mathematical content areas. The first four curriculum standards (i.e., mathematics as problem solving; mathematics as communication; mathematics as reasoning; and mathematical connections) as written for grades 5-8 in the NCTM *Curriculum Standards* are presented in Appendix J. Using these four curriculum Standards in conjunction with the NCTM *Professional Standards* recommendations for evaluating mathematics instruction yielded a simple yet detailed coding system which helped insure the validity of the Level I research analysis.

According to the *Professional Standards* (NCTM, 1991), evaluation of mathematics teaching should be based on information from a variety of sources which include analyses of multiple episodes of classroom teaching and teacher interviews. The *Professional Standards* further suggests that four major arenas of teachers' work are logically central to shaping what goes on in mathematics classes and, therefore, provide the categories for analyzing mathematics instruction (p. 20); they are tasks, discourse, environment and analysis. Following are abbreviated definitions provided by the *Professional Standards* (NCTM, 1991) for these categories. The full statements are located in Appendix K.

- *Tasks* are the projects, questions, problems, constructions, applications, and exercises in which students engage.
- *Discourse* refers to the ways of representing, thinking, talking, and agreeing and disagreeing that teachers and students use to engage in those tasks.
- *Environment* represents the setting for learning.
- *Analysis* is the systematic reflection in which teachers engage. (p. 20)

Coding Scheme Based on NCTM *Standards*

Pairing classroom instruction variables of task and discourse with the first four curriculum Standards (problem solving, communication, reasoning and connections) yields a coding system with eight categories for analyzing classroom observation and interview data for *what* is taught. To analyze data for *how* mathematics is taught these eight categories are combined with eight additional categories that result from pairing the last two classroom instruction variables, environment and analysis, as follows. Environment is paired with (1) task and discourse *related to content* (the first eight categories), and (2)with discourse that is *not content related*. Analysis is divided into (a) analysis of students' learning, referred to as *assessment*, and (b) analysis of instruction, referred to as *evaluation*. Assessment and evaluation are then paired with task, discourse, and environment to yield the last six coding categories. The result is the following coding system with 16 categories.

4— Task Categories: Problem Solving, Communication, Reasoning, Connections

4— Discourse Categories: Problem Solving, Communication, Reasoning, and Connections

2— Environment Categories: Task and Discourse related to content, and Discourse not related to content

6— Analysis Categories: Assessment related to Task, Discourse and Environment (3); and Evaluation related to Task, Discourse and Environment (3)

Tables 1, 2 and 3 present this coding system in a simple and organized fashion, but a more detailed explanation concerning the intentionally selected ordering and pairing of the categories is necessary. The categories or components of instruction (i.e., task, discourse, environment and analysis) are not easily separated from one another and in most cases are intertwined and dependent. Therefore, the order in which the research analysis occurs is significant. An explanation of the order, reasons for this order, and further justification for selecting these particular four categories as the focal points for the research analysis follows the Tables.

Table 1

What is Taught— Task and Discourse Related to Content

	Problem Solving	Communication	Connections	Reasoning
Task	1	2	3	4
Discourse	1	2	3	4

Table 2

How it is Taught — Environment Related to Task and All Discourse

	Task and Discourse Related to Content	Discourse not Related to Content
Environment	1	2

Table 3

How it is Taught— Analysis Related to Task, All Discourse and All Environment

	Task	All Discourse	All Environment
Assessment of Learning	1	2	3
Evaluation of Instruction	1	2	3

Task

Task was selected as the first category of focus for the analysis for three reasons: (a) it is the easiest to identify and separate from other components, (b) mathematical tasks are central to student learning because they determine the interest and involvement of the learner (NCTM, 1991, p.1), and (c) tasks define what mathematics is and what doing mathematics means (NCTM, 1991, p. 24). Consequently, tasks can facilitate significant classroom discourse, require students to reason about different strategies and outcomes and always serve as a significant element of the overall classroom environment (NCTM, 1991, p. 25). The actual learning opportunities for students are dependent on the kind of discourse that the teacher orchestrates (NCTM, 1991, p. 32). This natural link between discourse and task makes discourse the next logical step in the analysis.

Discourse

While the tasks frame and focus student opportunities for learning (NCTM, 1991 p.24), discourse is also directly linked to student learning opportunities (NCTM, 1991, p. 32). Steffe and Tzur's (1994) comparison of Piaget and Vygotsky's views on learning and their subsequent model for learning mathematics elaborates on and supports the NCTM's connection between discourse and learning; they write that Piaget considers learning to be subordinate to development and that while development is spontaneous, learning is provoked by situations, for instance by a teacher, with respect to some didactic point or by an external situation (p. 9). Although Piaget regarded the basic mental operations involved in mathematics learning (i.e., the concepts of reversibility, transitivity, recursion, reciprocity of relations, class inclusion, conservation of numerical sets, measurements, organization of spatial references (Piaget, 1980, p. 26 as cited in Steffe and Tzur)), as products of spontaneous reconstruction, he did not imply that the child was a solo player or that the development of these concepts was intentional but, rather, that they were a product of the child's interactions within his or her physical, social, and cultural environment (Steffe and Tzur, 1994 p. 10). In contrast Vygotsky takes exception with the idea that learning is subordinate to development and instead emphasizes the essential influence of learning on development (Vygotsky, 1978 in Steffe and Tzur, 1994); one of Vygotsky's basic tenets of education is that social interaction plays a major role in learning (Steffe and Tzur, 1994, p. 11). An interpreter of Vygotsky, van Oers (1992, p. 2 as cited in Steffe and Tzur, 1994), writes that an individual's learning is dependent on social interaction and that the qualities of an individual's thinking are generated by the organizational features of the social interactions.

Based on the belief that learning will always involve other people or external situations and will usually be intentional on the part of adults, Steffe and Tzur (1994) formulate a model of learning mathematics which retains the fundamental and essential points of both Vygotsky and Piaget. In their model mathematical learning is not perceived as being provoked as opposed to spontaneous; rather, maintains and emphasizes the cultural meanings of mathematics; by separating the intentionality of adults and the unintentionality of children, Piaget's independence of spontaneous reconstruction for the learner is also maintained (Steffe and Tzur, 1994, p. 12). The following passage from Steffe and Tzur (1994) which is based on the work of van Oers (1992) and Wertsch and Toma (1994) provides a clear description of the concept of cultural meanings of mathematics:

> . . .individual mental functioning is not a simple and direct copy of social interaction because of the genetic transformations involved in internalization. Internalization, the fundamental process involved in learning, makes it possible to hypothesize personal forms of what van Oers regarded as the cultural meaning of mathematics. The generalized knowledge and skills for dealing with the world that have been built up throughout cultural history, according to van Oers (1992), 'can be transformed into curriculum content and, as such, it can be taught. Personal meaning (sense), however, cannot be taught directly; it can only be built up by the involvement in an educative relationship' (p.3). Through one of his major concepts—the zone of proximal development—Vygotsky stressed that cultural meanings can become intermingled with personal sense through an educational process.
>
> By claiming that cultural meanings can be taught, we interpret van Oers as implying that through social interaction, children internalize the organizational features of the social interaction by means of their personal concepts. . . . (p.11)

In this model for learning mathematics, cultural meaning is not seen as independent of the knowledge of human beings but, rather, stresses the adults' or teachers' knowledge and how that knowledge can be used when working with children. Children cannot construct the teacher's knowledge because it is essentially inaccessible to them. The best the students or children can do is modify their own knowledge as a result of interacting with the teacher and with each other (Steffe and Tzur, 1994, p. 12). This model of learning supports the recommendations made by the NCTM (1991) which uses the following analogy to stress the importance of interaction, in this case in the form of discourse, and to highlight the teacher's role in providing meaningful learning experiences for students:

> Like a piece of music, the classroom discourse has themes that pull together to create a whole that has meaning. The teacher has a central role in orchestrating the oral and written discourse in ways that contribute to students' understanding of mathematics. (p. 35)

In most classrooms this type of discourse does not occur spontaneously, and it requires an environment in which everyone's thinking is respected and in which reasoning and arguing about mathematical meanings is the norm (NCTM, 1991, p.35). Just as discourse is shaped by the tasks in which the students are engaged, it is also influenced by the learning environment of the classroom; in turn the learning environment is shaped by the kinds of mathematical tasks and discourse in which students engage (NCTM, 1991, p. 61). This indicates that the next logical step in the research analysis is to focus on the learning environment.

Learning Environment

The learning environment is more than just the physical setting of desk, bulletin boards, equipment and posters; it forms a hidden curriculum that conveys what is important when learning and doing mathematics (NCTM, 1991, p. 56). Thus, the learning environment of the classroom is foundational to what students learn, and it is a key element in fostering the goals of the *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1991, p. 61). Establishing a learning environment that supports and encourages problem solving and a positive disposition towards learning in all students is an essential component of mathematics reform in all classrooms. The essence of such a learning environment is a pervasive spirit of inquiry which depends totally on the kinds of mathematical tasks and discourse in which students engage. Consequently, the research analysis for environment focuses on two aspects: (1) environment related to task and discourse specific to task, and (2) all other aspects of the environment.

These two perspectives provide data which reflect how the environment supports problem solving, communication, reasoning, and connections, and how the environment impacts students' dispositions towards learning. Guidelines for the analysis of this part of the research are based on an interpretation of two learning environment Standards presented in the *Professional Standards*. The first section of the *Professional Standards* is devoted to the *Standards* for Teaching Mathematics; Standard 5, Learning Environment, provides details concerning how mathematics teachers create learning environments that foster the development of students' mathematical powers (NCTM, 1991, p. 57). The second section provides the Standards for the Evaluation of the Teaching of Mathematics; Standard 8, Learning Environment, addresses teachers' abilities to create such environments. The researcher's interpretation of the information provided in these two Standards resulted in the development of the following six questions as guidelines for the analysis of classroom environment:

> (1) to what extent do tasks encourage problem solving, reasoning, communication, and connections;
>
> (2) to what extent does discourse emphasize problem solving, reasoning, communication and connections;
>
> (3) to what extent do the tasks and discourse create a student-centered classroom;
>
> (4) to what extent do the tasks and discourse used in the classroom convey that mathematics is a subject to be explored and created by individuals and, also, through collaboration with other learners;
>
> (5) to what extent does the teacher's use of resources and classroom space facilitate students in their role of active learners;
>
> (6) to what extent does the teacher's use of task and discourse favorably impact students' dispositions towards learning?

Creating a comfortable collaborative learning environment is dependent on teachers' skills in developing and integrating tasks, discourse, and environment in ways that promote student learning, and these skills can be enhanced through teacher's thoughtful analyses of their instruction (NCTM, 1991, p. 61).

<u>Analysis.</u>

The last category, analysis, is paired with each of the previous categories to study the classroom observation and interview data reflecting teachers' beliefs about learning, content knowledge, and pedagogical knowledge. Good mathematics instruction begins with teachers developing an understanding of what mathematical concepts and operations the learners bring to the classroom (NCTM, 1989; NCTM, 1991; Steffe and Tzur, 1994) and then, subsequently, assessing how well the tasks, discourse, and environment are working to foster the development of students' mathematical literacy and power (NCTM, 1991 p. 62). According to the NCTM (1991):

> Assessment of students and analysis of instruction are fundamentally interconnected. Mathematics teachers should monitor students' learning on an ongoing basis in order to assess and adjust their teaching. Observing and

listening to students during class can help teachers, on the spot, tailor their questions or tasks to provoke and extend students' thinking and understanding. (p. 63)

Teachers need to observe students' mathematical activities to understand their mathematical knowledge and to create activities which will foster growth. The learners' mathematics is not independent of the teachers' mathematical concepts and operations because it is constructed partially through their interactions with teachers' goals, intentions, language, and actions (Steffe and Tzur, 1994, p. 12); therefore, to improve instruction teachers must constantly evaluate what they and their students are doing and how that is affecting what students are learning.

This systematic evaluation of instruction should be evident in all stages of the lesson: (a) planning, (b) implementation, and (c) evaluation and assessment. Planning a mathematics lesson that reflects the intentions of the NCTM *Standards* requires that teachers use their knowledge of mathematical content and pedagogy to select or create worthwhile instructional tasks. According to the NCTM *Standards* , selecting worthwhile tasks depends on teachers' abilities to evaluate tasks on many levels (e.g., determining if they involve sound mathematical content; present concepts in a manner that is challenging, and interesting; provide opportunities for all students to be active participants; involve students in problem solving and reasoning; match the developmental needs of the students; and provide opportunities for students to share their thinking and understanding).

When implementing lessons, effective instruction depends on teachers' skill in using informal assessments (e.g., observing students' actions and work, and listening to their discussions and questions) and being flexible and knowledgeable enough to make appropriate adjustments in the lesson and discourse to enhance students' understanding (e.g., deciding what questions to pose; what student questions to respond to or incorporate into the lesson; what student explanations to pursue; when to pose questions to extend student's thinking; when to ask for explanations, and when to provide hints). After implementing lessons, good teachers use formal and informal assessments of student learning and thoughtful reflections to evaluate the effectiveness of tasks, discourse and environment and then use these data to make informed instructional decisions (e.g., noting modifications necessary to improve the lesson, deciding what concepts need to be presented differently, what student ideas to incorporated into the next lesson, and what to do next to challenge and extend student understanding). As teachers make these pre-, during-, and post- instructional evaluations and decisions, they reveal their beliefs about teaching and learning, their knowledge of mathematical content and pedagogy, and the extent to which there is agreement between their beliefs and actions.

Global Instructional Questions	Responses that characterize mathematics instruction supportive of reform
(3) What cognitive processes are involved in the lesson?	Teacher emphasizes and focuses on complex thinking and reasoning, a variety of problem solving strategies, constructing meaning, and reflection.
(4) What types of instructional strategies are used by the teacher?	Teacher uses a variety of combinations of individual instruction, small-group instruction, and whole-group instruction via an inquiry or discovery approach, guided questioning (focus on higher-level type questions) or demonstration.
(5) How is learning assessed?	Teachers use a variety of formal and informal assessment tools (e.g., interviews, classroom discussions, student demonstrations, projects, applications, constructions, oral explanations, written explanations, written tests) that provide students opportunities to demonstrate or explain their conceptual and procedural understanding of mathematics. Grades are determined by students' performance on multiple types of assessment, and assessment is an integral part of instruction. Listening to and valuing what students say. Teachers provide opportunities for students to participate in self evaluations, assessing their own progress.
(6) What is the purpose of assessment?	Teachers use informal assessment to gain insight into what students are learning and use this knowledge for making in-class instructional decisions (i.e., when to adapt ongoing instruction to make mathematical connections that lead to higher levels of mathematical abstraction —scaffolding), or to develop concrete, conceptual or procedural understanding; and to plan short- and long-term instructional challenges that match students' needs. Teachers use formal assessment to document students' growth in mathematics, to communicate students' progress to parents and to determine grades.

This set of guiding questions is not intended to be an all-inclusive list of points of focus for determining good mathematics instruction; it does, however, include the major

Level I: Analysis Structure

The categories described in the previous section provided a snapshot view of mathematics education at Pleasant Middle School; however, a more indepth research analysis was required to determine the match between ongoing instructional practices at Pleasant Middle School and the NCTM's recommendations for reform. Indicators of these sixteen categories were analyzed in terms of being (a) strongly supportive of the NCTM *Standards*, (b) supportive, (c) marginally supportive, or (d) weakly or nonsupportive of the NCTM *Standards*. Placing these two components of the research analysis into a matrix yielded an organizational format for completing Level I coding (see Table 4).

<u>Likert Scale Instructional Categories</u>

A four point coding system was designed ranking indicators of each category in terms of their supportiveness of mathematics instructional reform. For an extensive list of indicators that correspond to each ranking see Appendix L, Table L1. Rankings for each specific indicator for each category were determined using the following scale. The indicator was ranked as:

1 "weakly or nonsupportive" of reform if all aspects of the indicator were listed in Table L1 (see Appendix L) under the indicators that are "weakly or non-supportive" or there was no evidence of recommended reform in the teacher's instruction

2 "marginally supportive" of reform if there is one aspect of reform (an indicator that is listed in Table L1 (see Appendix L) under "clearly supportive" evident in the teachers instruction

3 "supportive of reform" if a majority of the aspects of the indicator are listed in Table L1 (see Appendix L) under "clearly supportive" of reform

4 "strongly supportive" of reform if all aspects of the indicator are listed in Table L1 (see Appendix L) under the indicators that are "strongly supportive" of reform

An overview of the conceptual framework for Level I of this study and criteria concerning how indicators were identified and labeled as clearly supportive, weakly or nonsupportive follow Table 4.

Table 4.
Level I Coding System

	Weakly or Nonsupportive	Strongly Supportive
Task = T		
Problem Solving = PrS	T-PrS1	T-PrS4
Communication = Com	T-Com1	T-Com4
Reasoning = Rea	T-Rea1	T-Rea4
Connections = Con	T-Con1	T-Con4
Discourse = D		
Problem Solving	D-PrS1	D-PrS4
Communication	D-Com1	D-Com4
Reasoning	D-Rea1	D-Rea4
Connections	D-Con1	D-Con4
Environment = E		
Environment Related to Task and Discourse Specific to Task	E-T/D1	E-T/D4
Environment Not Related Tasks and Discourse Specific to Task	E-NTD1	E-NTD4
Assessment and Evaluation		
Assessment of Learning and Task	AOL-T1	AOL-T4
Assessment of Learning and Discourse	AOL-D1	AOL-D4
Assessment of Learning and Environment	AOL-E1	AOL-E4
Evaluation of Instruction Related to Task	EOI-T1	EOI-T4
Evaluation of Instruction Related to Discourse	EOI-D1	EOI-D4
Evaluation of Instruction Related to Environment	EOI-E1	EOI-E4

Overview of Conceptual Framework

A model of the conceptual framework of Level I of this study is presented in Figure 2. The model demonstrates how all the individual components (i.e., tasks, discourse, environment and analysis) are related, and it facilitates the explanation of the conceptual framework.

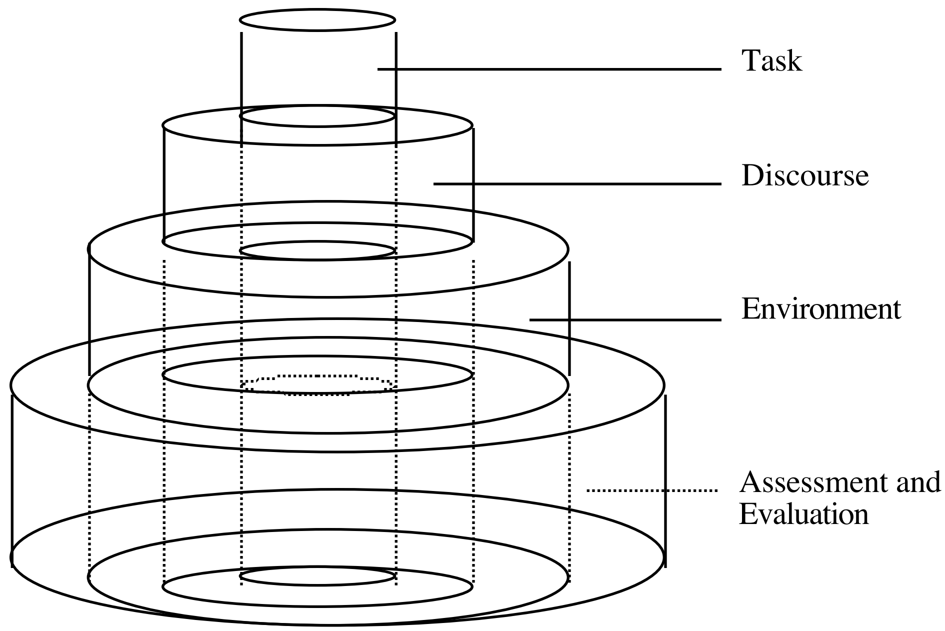

Figure 2. Model of Conceptual Framework.

Mathematical tasks are the pivotal component of this study and are depicted as the core of Figure 2; thus, the first step in analysis is to determine to what extent the instructional tasks observed are supportive of recommended reform. As mentioned earlier, the NCTM's first four Curriculum Standards (Mathematics as Problem Solving, Mathematics as Communication, Mathematics as Reasoning and Mathematical Connections) were used to develop a list of indicators (see Appendix L) for coding the tasks observed as supportive of problem solving, reasoning, connections, and mathematical communication. These four curriculum Standards are threads that permeate the core of good instructional tasks. Good instructional tasks that provide students with opportunities to develop mathematical understanding, reasoning skills, and number sense are characterized by authentic or interesting problem solving challenges which include multiple solution strategies, multiple representations, and mathematical communication. Each of the tasks observed was carefully deconstructed, analyzed and coded in terms of problem solving, connections, communication, and reasoning. These separate components were reconstructed and, based on the Likert Scale for Ranking Instructional Categories, the tasks were ranked as to what extent they were supportive of reform.

This same procedure was followed for coding the task in terms of discourse, the second concentric cylinder in Figure 2. “The development of logical reasoning is tied to the intellectual and verbal development of students.” (NCTM, 1989 p. 78) Students should be talking to each other as well as to the teacher. Classroom discourse should be representative of a community of learners (e.g., students discussing, communicating, and sharing their mathematical reasoning while constructing mathematical meaning). Each task observed was deconstructed, analyzed and coded in terms of discourse to determine to what degree the discourse used while implementing the task was supportive of reform. Indicators used for this part of the analysis focused on the cognitive demands of the task related to problem solving, making connections, communicating mathematically, and reasoning (see Appendix L). As before, these separate rankings were then reassembled to determine the overall ranking of discourse for this task.

For students to benefit from a discovery or inquiry approach to instruction the learning environment needed to support active participation in the mathematical tasks and discourse; environment was the third concentric cylinder in Figure 2. Creating an intellectual environment that fostered experimenting with alternative approaches to problem solving, making conjectures, and constructing mathematical meaning involved more than just the physical arrangement of the room (NCTM, 1991 p. 56). How teachers structured the use of class time, how teachers interacted with students, teachers’ expectations, and their classroom management styles were all hidden aspects of the environment that strongly influenced the learning process when a task was implemented. When coding each task in terms of classroom environment two different categories were used— environment related to task and discourse specific to task, and environment *not* related to task and discourse specific to task (e.g., classroom management, aspects of the physical environment , and teachers’ dispositions). Indicators used to rank the environment were based on recommendations from NCTM’s three sets of *Standards* and focused on the degree to which environment was supportive of reform type tasks and discourse (see Appendix L); as before, an overall ranking was determined for environment using the Likert Scale for Ranking Indicators.

Good teaching depends on constant analysis by teachers of what they and their students are doing and how that is affecting what students are learning (NCTM, 1991, p. 67); analysis is represented by the fourth concentric circle of the model in Figure 2. If the model is viewed in terms of layers, noting how one layer supports the next, it is obvious that analysis of instructional practices is the key component supporting good teaching. Teacher’s knowledge of content and pedagogy and their philosophical and pedagogical beliefs play major roles in determining types of instructional tasks selected, types and foci of discourse used in the classroom, and classroom environment.

Analysis for this portion of each task is divided into two categories: (a) assessment of students, and (b) evaluation of instruction. Indicators created to determine the degree to which assessment practices are supportive of reform focus on assessment and task; assessment and discourse; and assessment and environment. Likewise, indicators created to determine the degree to which teachers' evaluations of instructional practices are supportive of reform focus on evaluation and task; evaluation and discourse; and evaluation and environment. Both sets of indicators were developed using the NCTM's three *Standards* publications (see Appendix L), and overall rankings were determined by using the Likert Scale for Ranking Indicators.

Likert Scale for Overall Ranking of Individual Tasks

After each task was coded in relation to discourse, environment and analysis, scores for all four of these components of instruction were combined and the resulting sum was used to determine an overall ranking for each instructional task from its inception to its conclusion. An overall ranking for task indicates to what degree the task and related discourse, environment and analysis were supportive of mathematics reform. The resulting Likert Scale depicts the degree to which task and related instructional practices were supportive of reform as a continuum of possible sums from four to sixteen represented by the diagram in Figure 3.

4	5	6	7	8	9	10	11	12	13	14	15	16

Weakly supportive   Strongly Supportive

Figure 3. Overall Task Ranking Continuum

Weakly supportive of reform means the task and related instructional practices showed little or no evidence of instructional reform, and strongly supportive means the task and related instructional practices showed evidence that most or all aspects of instructional reform practices where implemented. For cases of mixed indicators overall rankings fell somewhere between four and sixteen as shown in Figure 4.

This Likert scale reflects the reality that reforming instructional practice is a learning process for teachers and that it is "a highly personal experience for the individuals involved in the process" (Gann, 1993). Involvement in the process is the key component for reforming instructional practice, and for many teachers involvement in the reform process translates to implementing this year's new idea (e.g., manipulatives, technology, cooperative learning) (Gann, 1993). Therefore, if teachers were active participants in the reform movement then it was likely that their instructional practices were in different stages of reform; not everyone started at the same place in terms of background nor in terms of the component of instruction that they chose to focus on first for making changes. This scale provided the basis for determining to what extent each teacher's instructional practice was supportive of reform.

4, 5, 6	Weakly or nonsupportive of reform
7, 8, 9	Marginally supportive of reform
10, 11, 12	Supportive of reform
13, 14, 15, 16	Strongly supportive of reform

Figure 4. Likert Scale Overall Task Ranking

Once a detailed analysis of each lesson's individual tasks was completed and each task was ranked in terms of its supportiveness of reform, it was then necessary to reconstruct all the individual pieces to provide an overview of each lesson and a global view of each teacher's mathematics instruction. The next topic to be addressed is the process for determining to what degree each teacher's instruction was supportive of recommended reforms in a *global sense* .

Global Ratings

Decisions concerning whether indicators representing a teacher's instruction in a global sense were labeled as strongly supportive of the NCTM's recommendations, supportive, marginally supportive, or weakly or nonsupportive were based on the NCTM's ultimate goal— mathematics teaching for the mathematical empowerment of all students. Just as the rankings for the four components of instruction (task, discourse, environment and analysis) were combined to determine the overall-task ratings, the process for making global ranking decisions for each teacher's mathematics instruction started with reconstructing the mathematics lessons from their individually analyzed components of instruction.

Each lesson's overall-task rankings were arranged in order from the opening task to the closing task and the Global Rating Likert Scale was used to determine an overall ranking for each lesson and a global rating for each teacher's instruction. Before assigning a global rating for each teacher's instruction, the two day follow-up observations were analyzed using this same procedure, and overall lesson rankings for each set of classroom observations were compared. The Global Rating Likert Scale is based on the same principal as the overall task ranking scale, but since the number of tasks varied from lesson to lesson the average of tasks' overall rankings that made up a lesson was used to determine the extent to which the lesson was supportive of reform. Global Ratings for teachers' overall instructional practices were based on the averages of the global rankings for the five lessons observed. The averages were rounded to the nearest whole number; thus, the same scale designed for overall task rankings fits Global Ratings as shown in Figure 5.

The detailed analysis and structured organization of the data which resulted in an individual teacher's global rating were actually more significant to the results of the study than its end result, a global rating for each teacher's instruction. The teacher's global rating for instruction in conjunction with supporting data fulfilled the two goals of this part of the study: (a) they provided data for making comparisons and generalizations about mathematics instruction across three observed grade levels, and (b) they provided data for making valid conclusions concerning the extent to which mathematics instruction at this middle school matched the NCTM *Standards*. The next step in analysis, Level II, focused on determining specific matches between current instruction and reformed instruction, and, subsequently, on documenting if any of the matches in current instruction and reform have resulted from changes in instruction since participating in the V-QUEST Lead Teacher Program. Procedures for Level II Data Analysis follow.

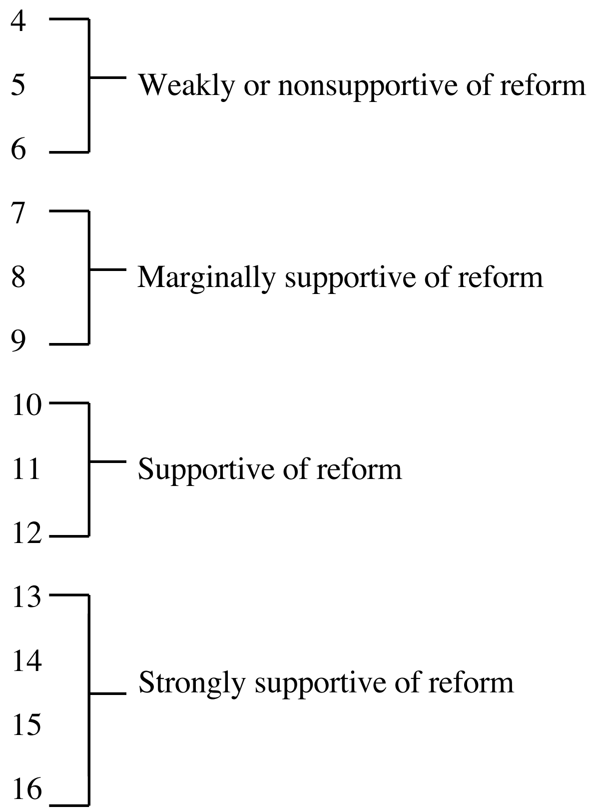

Figure 5. **Global Ratings Likert Scale**

Level II: Analysis Procedures

Details related to documenting specific matches between teachers' current instructional practices and recommended reformed instructional practices, and an explanation of how the resulting data were used in documenting teacher change are presented in this section. After providing the rationale for analysis procedures and justification for decisions related to development of the six organizational categorizes, a description of how this specific set of guiding questions was used to document matches between current instruction and recommended reform is provided. Finally, this section presents an explanation of how triangulation among classroom observations, teachers' interview data and artifacts were used to document changes in mathematics instruction since involvement with V-QUEST.

Rationale and Justification for Guiding Questions

Level II analysis started by deconstructing the lessons' coded components of instruction and reorganizing them into six categories significant to mathematics instructional reform. The NCTM *Curriculum Standards* offered specific suggestions for shifts in instruction and assessment necessary for changes in instructional practice. These suggestions along with pertinent information provided by the *Professional Standards* were used to develop the six organizational categories. The specific Standards used from the *Professional Standards* were the first three Standards for Evaluation of the Teaching of Mathematics: Standard 1: The Evaluation Cycle; Standard 2: Teachers as Participants in Evaluation; Standard 3: Sources of Information; and Standard 6: Analysis of Teaching and Learning from the Teaching Mathematics *Standards*. Following the NCTM *Standards'* suggestions for changing classroom instruction is a description of how this information was used to create these six organizational categories for documenting change.

The NCTM *Standards* and Change in Classroom Instruction

Good mathematics instruction, instruction that empowers all students, is dependent upon teachers selecting and implementing challenging, worthwhile mathematical tasks that involve students in *doing* mathematics, discussing mathematics and constructing mathematical meaning. In their endeavor to help teachers implement this type of mathematics instruction the *Professional Standards* (NCTM, 1991) identified five major shifts in mathematics instruction as necessary for changing instructional practice. Those shifts are

- toward classrooms as mathematical communities—away from classrooms as simply a collection of individuals;
- toward logic and mathematical evidence as verification—away from the teacher as the sole authority for right answers;
- toward mathematical reasoning—away from merely memorizing procedures;
- toward conjecturing, inventing, and problem solving—away from emphasis on mechanistic answer-finding;
- toward connecting mathematics, its ideas, and its applications—away from treating mathematics as a body of isolated concepts and procedures. (NCTM, 1991, p. 3)

These five major shifts and previously related suggestions from NCTM's (1989) first four curriculum Standards (i.e., problem solving, communicating, making connections and reasoning) not only provide a rationale for making decisions concerning the global status of each teacher's instruction, but they also identify aspects of instruction that have the potential to provide evidence of change.

In conjunction with the NCTM's suggested shifts in instruction are corollary suggestions for changes in assessment. *Assessment Standards for School Mathematics* (*Assessment Standards*) (NCTM, 1995) states, ". . .if students are to increase their mathematical power, several related shifts in assessment practice are warranted. . ." (p. 29). In general, decisions concerning the assessment and evaluation indicators related to assessment of students learning were based on the following suggested shifts in monitoring students' progress:

- A shift toward judging the progress of each student's attainment of mathematical power, and away from assessing students' knowledge of specific facts and isolated skills
- A shift toward communicating with students about their performance in a continuous, comprehensive manner, and away from simply indicating whether or not answers are correct
- A shift toward using multiple and complex assessment tools (such as performance tasks, projects, writing assignments, oral demonstrations, and portfolios), and away from sole reliance on answers to brief questions on quizzes and chapter tests
- A shift toward students learning to assess their own progress, and away from teachers and external agencies as the sole judges of progress ((NCTM, 1995, p. 29)

Additional details for guiding decisions concerning changes in methods of assessment came from the first three evaluation Standards found in the *Curriculum and Evaluation Standards* (NCTM, 1989).

Interest in assessment for this part of the study was two-fold: (a) *methods* of assessment used by teachers, and (b) *purposes* of particular assessments. Of the twelve Evaluation Standards included in NCTM *Curriculum Standards,* the first three focus on General Assessment; they provide information relevant to changing methods of assessment. The first Evaluation Standard is Alignment; for the purpose of this study alignment with the curriculum means alignment with the curriculum goals suggested by NCTM *Curriculum Standards*. These three General Assessment *Standards* (Alignment, Multiple Sources of Information, and Appropriate Assessment Methods and Uses) provided the principles for judging assessment instruments appropriate for an instructional environment that fostered deeper understandings of mathematics (NCTM, 1989). Following are the General Assessment *Standards*:

Standard 1: Alignment

Method and tasks for assessing students' learning should be aligned with the curriculum's—

- goals, objectives, and mathematical content;
- relative emphases given to various topics and processes and their relationships;
- instructional approaches and activities, including the use of calculators, computers, and manipulatives. (p. 193)

Standard 2: Multiple sources of information

Decisions concerning students' learning should be made on the basis of a convergence of information obtained from a variety of sources. These sources should encompass tasks that—

- demand different kinds of mathematical thinking;
- present the same mathematical concept or procedure in different contexts, formats, and problem situations. (p. 197)

Standard 3: Appropriate assessment methods and uses

Assessment methods and instruments should be selected on the basis of—

- the type of information sought;
- the use to which the information will be put;
- the developmental level and maturity of the student. (p. 199)

Assessment is an integral part of effective teaching, and periodic assessment should provide teachers with a basis for deciding what questions should be asked and what examples and/or illustrations should be used; ultimately, it offers a foundation for any meaningful dialogue between teachers and students. It is at this level that the most important decisions about teaching and learning are made (NCTM, 1989, p. 203). NCTM's (1995) *Assessment Standard*, Purpose: Making Instructional Decisions, and NCTM's (1991) *Professional Standard*, Analysis of Teaching and Learning supplemented information used to guide the researcher's decision-making concerning the purpose of assessment indicators.

How assessment is used to make instructional decisions was identified as the primary question addressed in the *Assessment Standard*— Purpose: Making Instructional Decisions (NCTM, 1995). The response to this question provided three ways that evidence gathered from assessment about learning could be used to make instructional decisions:

(1) to examine the effects of the tasks, discourse, and learning environment on students' mathematical knowledge, skills and dispositions;

(2) to make instruction more responsive to students' needs; and

(3) to ensure that every student is gaining mathematical power. (p.45)

To facilitate teachers' application of these types of instructional evaluations and decisions, the *Assessment Standards* suggested the following shifts in assessment practices:

- toward integrating assessment with instruction (to provide data for moment-by-moment instructional decisions) and away from depending on scheduled testing (generally useful only for delayed instructional decisions);
- toward using evidence from a variety of assessment formats and contexts for determining the effectiveness of instruction and away from relying on any one source of information (often, in the past, paper-and-pencil tests);
- toward using evidence of every student's progress toward long-range goals in instructional planning and away from planning for content coverage with little regard for students' progress. (p. 45)

As mentioned, these suggestions concerning how assessment can facilitate instructional decisions and how assessment practices can change to accommodate these decisions are part of the informational basis used for identifying instructional indicators of change in methods and purposes of assessment. One significant change in the purpose of assessment is for teachers to make decisions concerning the whole learning community instead of focusing solely on individual performance and individual needs. Assessment should be the primary source of information for planning and improving both short and long term instruction (NCTM, 1991, p. 62); thus, an intimate relationship between evaluation of instruction and assessment is formed (NCTM, 1991, p. 67).

Both *how* the teacher should assess students and the *purpose* of assessment in of instructional evaluation are addressed in the NCTM *Professional Standards*. Standard 6: Analysis of Teaching and Learning emphasized the importance of monitoring students' learning on an ongoing basis to assess and adjust their own instruction stating:

Standard 6: Analysis of Teaching and Learning

The teacher of mathematics should engage in ongoing analysis of teaching and learning by—

- observing, listening to, and gathering other information about students to assess what they are learning;
- examining effects of the tasks, discourse, and learning environment on students' mathematical knowledge, skills, and dispositions;

in order to—

- ensure that every student is learning sound and significant mathematics and is developing a positive disposition toward mathematics;
- challenge and extend students' ideas;

- adapt or change activities while teaching;
- make plans, both short- and long-range;
- describe and comment on each student's learning to parents and administrators, as well as to the students themselves. (NCTM, 1991, p. 63)

The next section explains and offers supporting arguments concerning how all these individual elements of the NCTM *Standards,* lists of suggestions and related Standards, were used to create the six categories of focus for documenting change.

Justification for Guiding Questions

Cross referencing all these change-related sections of the NCTM *Standards* (*Evaluation Standards*, *Assessment Standards* and *Professional Standards*) with the recommended shifts in mathematics instruction and assessment yielded a set of common questions that served as guidelines for making global decisions concerning how each teacher's mathematics instruction specifically matched the NCTM's recommendations for reformed instruction. Since this portion of the study focused on identifying matches in current practice with recommended reform, responses for these questions were limited to characteristics of mathematics instruction that were supportive of reform. Based on details and descriptions provided in the NCTM *Standards* of mathematics instruction supportive of reform, responses to each of the questions characterize components of mathematics instruction supportive of reform. The six guiding questions and related responses that resulted from detailed analysis of the NCTM *Standards* are presented in Table 5.

Table 5

Guidelines for Matching Instruction to NCTM Recommendations

Global Instructional Questions	**Responses that characterize mathematics instruction supportive of reform**
(1) What type(s) of instructional tasks are used for instruction?	Teacher selects and uses a variety of nonroutine problems, applications, questions, projects, constructions, or exercises which may or may not be from the textbook, that challenge the students to investigate and construct mathematical concepts and relationships.
(2) Is instruction student-centered or teacher-centered?	Teacher regularly provides opportunities for the students to explain, justify and demonstrate their reasoning in small-group and whole-group situations.

(table continues)

Global Instructional Questions	**Responses that characterize mathematics instruction supportive of reform**
(3) What cognitive processes are involved in the lesson?	Teacher emphasizes and focuses on complex thinking and reasoning, a variety of problem solving strategies, constructing meaning, and reflection.
(4) What types of instructional strategies are used by the teacher?	Teacher uses a variety of combinations of individual instruction, small-group instruction, and whole-group instruction via an inquiry or discovery approach, guided questioning (focus on higher-level type questions) or demonstration.
(5) How is learning assessed?	Teachers use a variety of formal and informal assessment tools (e.g., interviews, classroom discussions, student demonstrations, projects, applications, constructions, oral explanations, written explanations, written tests) that provide students opportunities to demonstrate or explain their conceptual and procedural understanding of mathematics. Grades are determined by students' performance on multiple types of assessment, and assessment is an integral part of instruction. Listening to and valuing what students say. Teachers provide opportunities for students to participate in self evaluations, assessing their own progress.
(6) What is the purpose of assessment?	Teachers use informal assessment to gain insight into what students are learning and use this knowledge for making in-class instructional decisions (i.e., when to adapt ongoing instruction to make mathematical connections that lead to higher levels of mathematical abstraction —scaffolding), or to develop concrete, conceptual or procedural understanding; and to plan short- and long-term instructional challenges that match students' needs. Teachers use formal assessment to document students' growth in mathematics, to communicate students' progress to parents and to determine grades.

This set of guiding questions is not intended to be an all-inclusive list of points of focus for determining good mathematics instruction; it does, however, include the major points of focus identified by the NCTM *Standards*. When compared with a similar list, "Components of the Role of the Teacher in a Reformed Classroom," designed by Clarke and shared in both his 1993 and 1997 publications, the points of focus are the same as those used in this study. Clarke (1993, p. 27) based his list on common themes of the teacher's role described in the following studies: Cobb, Wood, and Yackel, 1990; de Lane, va Reeuwijk, Burrill, & Romberg, in press; Fennema, Carpenter, & Peterson, 1989; Lampert, 1988; Middle Grades Mathematics Project 1988; Schoenfeld, 1987; Stephens & Romberg, 1985. Clarke's (1993) list of six components follows.

> 1. The use of non-routine problems as the starting-point and focus of instruction, without the provision of procedures for their solution
> 2. The adaptation of materials and instruction according to local contexts and the teacher's knowledge of students' interests and needs
> 3. The use of a variety of classroom organizational styles (individual, small-group, whole-class)
> 4. The development of a "mathematical discourse community," with the teacher as "fellow player" who values and builds upon students' solutions and methods
> 5. The identification and focus on the big ideas of mathematics
> 6. The use of informal assessment methods to inform instructional decisions (p. 38)

Both lists, the Guiding Questions for Level lI of this study and Clarke's Components of the Role of the Teacher in the Reformed Classroom, begin with worthwhile mathematical tasks as the core component of instructional reform. How the remainder of Clarke's components of the role of the teacher match this study's guiding questions for making global decisions about mathematics instruction supportive of reform is explained in the following paragraph, and this correlation is presented in Table 6.

Clarke's second item, adaptation of materials and instruction..., is based on the belief that mathematics needs to be studied in living contexts that are meaningful and relevant to the students' needs and interests (Clarke, 1993). This corresponds to this study's guiding question, "What is the purpose of assessment?" because they both focus on how teachers use assessment to gain insight into what students are learning, how this knowledge is used for making in-class instructional decisions and to plan short- and long-term instructional challenges that match students' needs. His third item, the use of a variety of classroom organizational styles, corresponds to this study's guiding question, "What types of instructional strategies are used?" because both items are concerned with how the teachers use a variety of combinations of individual instruction, small-group instruction, and whole-group instruction via inquiry, discovery, and demonstration. Clarke's fourth component, the development of a mathematical discourse community..., corresponds to this study's guiding question, "Is instruction student-centered or teacher-centered?" because both focus on the need for teachers to provide opportunities for students to construct mathematical meaning by making conjectures, justifying conclusions, discussing alternative solutions, and demonstrating understanding. The fifth component of Clarke's role of the teacher in a reformed classroom, the identification and focus on the big ideas of mathematics, corresponds two of this study's guiding questions, "What cognitive processes are used/" and, "What is the purpose of assessment?" because they both focus on the importance of teaching mathematics as an integrated whole with an emphases on problem solving, reasoning and communication instead of teaching specific procedures in isolation. The last component of Clarke's role of the teacher in a reformed classroom, the use of informal assessment. . ., corresponds to this study's guiding question, "How is learning assessed?" because both are concerned with teachers' observing and listening to students explain their thinking instead of just checking correct answers on a written test. After establishing the guidelines for analyzing teachers' instruction, the next step was to match indicators from the components of instruction (task, discourse, environment and analysis) that were identified as supportive of reform in Level I responses to the guiding questions.

Table 6

The Role of the Teacher in the Reformed Classroom: A comparison of Clarke's Components and the Guiding Questions Developed for the Present Study

Clarke (Role of the Teacher)	Present Study (Guiding Questions)
Worthwhile mathematical task	What type(s) of instructional tasks are used?
Adaptation of materials and instruction (instructional designed to fit students' needs and interests)	Purpose of assessment?
Use of a variety of organizational styles	Types of instructional strategies used?
Mathematical discourse community	Is instruction student-centered or teacher-center?
Identification of the big idea (treating mathematics as an integrated whole)	What cognitive processes are used? and What was the purpose of assessment?
Use of informal assessment	How is learning assessed?

After the responses were selected and written, indicators of supportive components of instruction were sorted to match the responses, and three indicators were identified for each question. All three items (questions, responses and matching indicators) are presented in Appendix M, Table M1. How these six guiding questions and related indicators were used to document specific matches between teacher's current instructional practices and recommended reform is presented in the next section.

Procedures for Documenting Reformed Instruction

At the end of the Level I analysis, coded components of instruction (task, discourse, environment, analysis) were summarized, and generalizations were made about instructional practices observed compared to the NCTM *Standards*' recommendations. The focus in the next portion of the study was narrowed to *good instruction*. Using the summary chart (see Appendix N) of Overall Instructional Rankings any component of instruction that was coded as three or four was targeted for a more detailed analysis to pinpoint the exemplary instructional practice being cited; each was then tracked throughout all five lessons to determine if it was a practice in which the teacher engaged routinely. Any good instructional practices thus identified were subsequently analyzed for change over time.

Two organizational systems were used for this part of the study. As in Level I, analysis began with a focus on tasks. The data were organized by lessons in a matrix which sorted the tasks by type (practice, exercise, problem solving, application, construction, project) and by sequence (position in the lesson: 1st, 2nd,. . .). Coded indicators resulting from the six guiding questions were recorded in each cell (see Tables N1 and N2, respectively, in Appendix N), and then good instructional practices were identified. All of these identified indicators were then analyzed for change over time.

In addition to instructional data specific to the eighteen indicators determined as good instructional practice, this matrix facilitated an analysis of the "model of instruction" used by the teacher which provided insight into the extent to which teacher's actions match his/her beliefs about learning. By examining all five lessons, the typical instructional routine or model of instruction was identified and labeled as a traditional model of instruction or a reform model of instruction. Instructional routines were considered typical professional practice if they were present in at least three out of five lessons observed. Descriptions of traditional and reform views of learning and models of instruction follow.

Analysis of teachers' typical instructional practices provided insight as to how the students were learning. In the traditional view of learning mathematics, students are "blank slates" onto which information is etched by the teacher (Brooks and Brooks, 1993). Brooks and Brooks describe the traditional model of instruction as follows, ". . . concept introduction comes first, followed by concept application activities. Discovery, when it occurs, usually takes place after introduction and application, and with only the ‘quicker’ students who are able to finish their application tasks before the rest of the class.”

In a reform view of learning, students are viewed as thinkers with emerging theories about the world (Brooks and Brooks, 1993, p. 17). Brooks and Brooks describe the reform model of instruction as follows:

> First, the teacher provides an open-ended opportunity for students to interact with purposefully selected materials. The primary goal of this initial lesson is for students to generate questions and hypotheses from working with materials. This step has historically been called ‘discovery.’ Next, the teacher provides the ‘concept introduction’ lessons aimed at focusing the students’ questions, providing related new vocabulary, framing with students their proposed laboratory experiences, and so forth. The third step, ‘concept application,’ completes the cycle after one or more iterations of the discovery-concept introduction sequence. During concept application, students work on new problems with the potential for evoking a fresh look at the concepts previously studied. (p. 117)

The researcher used the following process to identify the model of instruction representative of each teacher’s typical practice. Each lesson was mapped, and instructional maps common to at least three lessons automatically determined that teacher’s typical model of instruction. After mapping each teacher’s typical model of instruction it was compared to the map of reformed instruction in Figure 6. Any matches between teachers’ typical practice and this model of instruction were tracked in the research data for evidence of change in beliefs about learning and subsequent pedagogical changes.

Discovery—> Concept Introduction—>Concept Application—>Discovery

Figure 6. Model of reform instruction.

To facilitate analysis related to questions which focus on a teacher’s use of a variety of instructional strategies, models, assessment tools and tasks, each teacher’s data was summarized in a second matrix which paired types of tasks with the teacher’s five lessons. Recorded in each cell was a summary of the frequency of each type of task, textbook or not textbook related, type of instruction, type of assessment, and ranking as supportive or not supportive of reform. Summaries that indicated instructional practices compatible with the NCTM’s reformed classroom were also analyzed in terms of change. How the research data were used to document change in instructional practices since participation in V-QUEST is presented in the next section.

The Use of Triangulation to Document Change

All instructional indicators coded as supportive of reform from the classroom observation data were tracked through the interview data and artifacts to determine if teachers had indeed made intentional changes in their classroom instructional practices. Triangulation occurred between two or more of the following sources: interviews related to change, observations in the classroom, and artifacts that portrayed the traditional or original method before change (baseline data). If the teachers were working together with other teachers or administrators then corroborating evidence was provided by interview data and classroom observations of coworkers.

A list of possible artifacts for establishing baseline data for the six questions guiding this part of the study are listed in the data collection section of this study, but as the study evolved some artifacts became more useful than others. Written lesson plans for past and current instruction proved to be unavailable, but records of purchase orders for mathematics instructional materials, an inventory of mathematics supplies and copies of classroom instructional materials used to teach or assess the same lessons observed prior to participation in V-QUEST were made available as well as the newspaper clippings from each year's events in the school's scrapbooks. All these artifacts were used to triangulate. Any aspects of instruction that were documented as reformed since participation in V-QUEST were considered in Level III for documenting systemic reform in this middle school. The process of documenting systemic reform is described next in analysis procedures for Level III.

Level III: Analysis Procedures

Documenting systemic reform for this middle school entailed looking at all levels of reform (classroom, building, division and state) from the perspective of each mathematics teacher who had the ultimate responsibility for implementing reform mandates, policies and programs. For completing Level III analysis, classroom observation and interview data from Levels I and II were combined with interview data related to teachers' professional responsibilities outside the classroom and interview data concerning administrative support of educational reform. A coding system for analysis of all interview data was created using the same matrix (see Appendix M) designed to organize and structure data collection interviews. Explanations of this coding system and how it was designed are followed by details of how these coded indicators and the systemic reform data collection matrix were used to document systemic reform.

Level III: Coding System

Systemic reform was documented by comparing indicators from the research data with the systemic reform indicators developed for the criterion-based assessment component of the V-QUEST Systemic Reform Program. As noted in the data collection section of this study, the major links between instructional practice in classrooms and building, division and state levels of educational administration were (a) curriculum, (b) assessment, (c) instructional materials, and (d) technical assistance. These four levels of systemic reform, along with the four linking areas, were combined with the thirteen V-QUEST Systemic Reform Indicators to create a coding system for Level III data analysis (see Table 7).

Table 7

Level III Coding Matrix

Systemic Indicators	**Attribute Codes**												
	Population				**Linking Area**				**Stage of Reform**				
	L1	**L2**	**L3**	**L4**	**A**	**C**	**IM**	**TA**	**S1**	**S2**	**S3**	**S4**	**S5**
TeleCNP													
Conf/ProM													
TeleCPD													
Ped/EdR													
InM													
Collab													
Commin													
Univer													
CurSS													
CurSL													
AdmLS													
FianS													
Assess													

Codes for the thirteen systemic indicators (see Appendix O) were created as well as subsequent attribute codes for each level (classroom, building, division and state), linking area(s) of focus (curriculum, assessment, instructional materials, and technical assistance), and codes to indicate to what extend this aspect of reform was achieved (implemented successfully, implemented and abandoned, implemented but needs work, implementation in progress, planning implementation, informed but no action taken). These codes are presented in Appendix N, Tables N1 and N2.

Level III: Coding System and Process of Analysis

These two sets of codes, systemic reform indicators (see Appendix O) and attribute codes, were used to create a matrix which provided the coding system for the Level III data analysis. The organizational structure presented in Table 7 resulted in a two-step coding process. First, systemic reform indicators were identified, and then specific attributes pertinent to documenting systemic reform were coded for each indicator. The matrix not only provided the coding system for Level III data but also served as an organizational structure for analyzing coded indicators to determine instances for cells in the matrix for documenting systemic reform.

The matrix was adapted to create an analysis summary sheet for organizing coded data for each interview using the thirteen systemic reform indicators and the three coded attributes (population, linking area, stage of reform) (see Appendix O, Table O1). Page numbers and brief descriptions of any systemic reform indicators identified during the coding process were recorded in the appropriate cells of the matrix. The resulting summary sheets facilitated the process of matching systemic indicators of reform to specific cells in the matrix designed for documenting systemic reform. Once all the coded data were assigned, the resulting matrix provided data for summarizing this study's documentation of systemic reform (see Table 7). Results of the analysis of Levels I, II and III are presented in Chapters Four, Five and Six respectively.

Summary

This chapter provided a rationale for and description of the research methodology. An overview of the structural design of the case study explained how three interrelated levels of the study were used to document systemic reform, and each of these levels was identified and defined. Details concerning data collection for each of these three levels explained who was interviewed and/or observed, why they were interviewed and/or observed, how the interviews and/or observations were structured and organized, and when they occurred.

Analysis procedures for the three levels of analysis were presented in detail beginning with a rationale for analysis procedures for Level I. That section defined the four components of instruction (task, discourse, environment, and analysis) used to analyze observation and interview data and provided the coding scheme, structure of the analysis, an overview of the conceptual framework, and the Likert scales designed for making generalizations concerning instructional practices. Procedures for Level II explained how artifacts were used to establish baseline data, and how six guiding questions and results from Level I analysis were used to document evidence of reform and change in instructional practice. Analysis procedures for Level III presented the coding scheme and structure of analysis for documenting evidence of systemic reform. Results of these analysis procedures are presented in the next three chapters.

Chapter IV

Level I Analysis: A Snapshot View Of Mathematics Education In Pleasant Middle School and Identifying Instructional Reform

The findings of this study are presented in three separate chapters that correspond to the three levels of the study as described in the methodological section. Since there were two goals for Level I analysis, to (1) provide a snapshot view of mathematics education, and (2) identify any matches between observed instructional practice and the NCTM's recommended instructional reforms, Level I analysis results are presented in two sections. The chapter begins with a descriptive analysis of the participant classroom observations to provide snapshot views of the sixth, seventh and eighth grade teachers' typical mathematics lessons. In section two the classroom observation overall-task ratings and global ratings are shared to document any instructional reform matches. Before the analysis results are shared a presentation of selected vignettes that exemplify instruction associated with each of the four global ratings (strongly supportive, supportive, marginally supportive and weakly or nonsupportive) are presented. The presentation of the classroom-observation analysis results for each teachers' initial and follow-up observations is followed by a comparison of those results to verify consistencies or inconsistencies in instructional practice and to support the global ratings assigned.

Level I Analysis: A Snapshot View Of Mathematics Education In Pleasant Middle School

This section provides a comparative summary of the mathematics instruction observed in each participant's classroom. Although each description was as individual as the teacher who was observed, all the descriptions contain details about the four components of instruction, task, discourse, environment and assessment/evaluation, the focus of Level I the analysis. These data were used to create a snapshot view of the mathematics instruction observed for each teacher which included details about his or her teaching style, generalizations about types of instructional tasks and strategies used by the teacher, information about how he or she planned for mathematics instruction and details about the learning environment. The descriptions were organized by grade level beginning with the eighth grade teachers and ending with the sixth grade teachers.

Eighth Grade Teachers

When thinking about the mathematics lead teacher, Mr. A., words like organized clutter or managed chaos came to mind. He was the type of person who had dozens of things going at one time; for example, during the course of the study he was running a school-wide paper recycling project, grading scale model projects prepared by his students, evaluating the progress of the school ground beautification project, launching a letter writing campaign as an attempt to secure needed classroom supplies for hands-on type instructional activities, organizing and stocking a teacher resource room, exploring the uses of technology for mathematics instruction, preparing a teacher inservice program for taking a problem solving approach to teach mathematics, doing bus duty before and after school, sponsoring one of the school sock hops, implementing a field trip to a local penitentiary, arranging for faculty members to attend the next NCTM conference, and to get away from it all running a working plant nursery.

His teaching style was best described as spontaneous; when asked to see his lesson plans he pointed to his head and said "I keep them all up here." This is not to say that Mr. A teaches without planning; there were numerous indicators of planning, i.e., materials for an activity were assembled and organized ahead of time, objectives listed on the board prior to class, or Mr. A sharing the results he got when he tried this activity earlier at home. Spontaneous teaching meaning not rigidly following lesson plans but rather going into the classroom with the idea that the lesson will evolve based on student needs and interests that emerge through directed interactions. This type of instruction depends on the use of on-going assessment and knowledge of mathematics, and Mr. A was comfortable and adept at making on the spot decisions to refocus or redirect the lesson.

Mr. A's classroom looked busy; with minimal storage facilities Mr. A had every available surface and space packed and stacked. One of the first things the researcher noticed when she walked into Mr. A's mathematics class was his desk piled so full of books, notebooks and papers that it spilled over to cover an adjoining table, and then to the surrounding floor area. Student-made mathematics posters were hung on a line that stretched around the two walls that weren't covered with windows or a chalkboard, and every file cabinet top or desk top that wasn't used by a student served as storage for something. There were baskets and small boxes filled with glue, scissors, markers, tape, rulers, protractors, straws, string, paper clips, paper, pens, and calculators. In the back of the room there was a table with a computer and printer with books and papers all around and student-made projects all around, but in the center of the room the student tables that accommodated two chairs each were arranged neatly in straight rows. This arrangement made it easy for Mr. A to walk around and talk to the students and for students to talk to each other. Mr. A's classroom reflected his energetic interactive style of teaching as well as the enthusiasm and love for mathematics that he promoted.

Mr. A used a variety of instructional strategies during each of the five 84 minute lessons observed, and his usual practice was to included at least one of each of the following type instructional strategies in every lesson: cooperative learning, whole-group discussion, direct instruction or inquiry, independent practice and individual instruction. A typical mathematics lessons in Mr. A's room was depicted by the objectives listed on Mr. A's board for his March 4th lesson:

1) Review 15 minutes
2) Obj [Standards of Learning Objectives] 5, 6, 7 20 minutes
3) Discussion Hover Craft 20 minutes
4) P. [page] 188-189 Problem Solving

The objectives referred to in item number two were from the 1988 *Standards of Learning* which were still in effect at the time of this observation:

8.05 The student will express equivalent relationships between fractions, decimals, and percents.
8.06 The student will find a given percent of a number and what percent one number is of another.
8.07 The student will solve simple linear equations in one variable. (p. 21)

This class opened with independent practice on nine problems that Mr. A had written on the board. He designated ten minutes for work time and five minutes for discussion but the discussion went much longer than five minutes. As the students worked Mr. A walked around the room and made informal assessments of the students' progress, and as he did this he commented on problems that were correct and asked leading questions about the problems that were not correct or that had stumped the students. For example problem three was write (a + b) (a + b) in exponential notation, Mr. A looked at a student's paper and then asked, "What's the base and how many times has it been used as a factor?" After ten minutes of this type of interaction Mr. A went to the overhead to go over the problems. He used whole-group inquiry to engage the students in explaining why the solution they offered was the answer to the problem. The following excerpt provided an example of Mr. A's use of inquiry style of instruction:

Mr. A . . . Look at number one. Give me the answer and explain why.
[Volunteers hold up their hands, and Mr. A calls on one of those students.]
Student #1: 4a
Mr. A: No
Student #1: a4 [Mr. A takes five seconds to quietly talk to this student]
Student #2: a to the fourth power.
Mr. A: a to the fourth power. Why's it a to the fourth power [John]?
Student #3: Because [voice becomes so low its not audible]
Mr. A: He said a times a times a times a is a to the fourth power, why?

Student #3: a is used as a factor four times.

Mr. A: a is used as a factor four times, very good. We're picking up on some vocabulary. Any questions? (3 seconds) Number two is a little bit different. . . .

The review continued in this fashion with Mr. A asking why after each problem was answered. He consistently used leading questions to get the students to think about the reasons why the answers were what they were. When appropriate Mr. A used questions to extend the problem solutions to making generalizations, and then he created new, related challenge problems for the students to try out their ideas. The discussion of problem number four provided an example of this, and that exchange follows:

Mr. A: OK, number four [$a^5 * a^6$] a to the fifth power times a to the sixth power. [Travis].

Student: a to the eleventh

Mr. A: Why is it a to the 11th? John?

Student #2: [inaudible response]

Mr. A: He said, a to the fifth plus a to the sixth is a to the 11th, tell me why. [Jason].

Student #3: Because you said that any time that you have to multiply a variable with exponents you add the exponents.

Mr. A: But why did I say that? [3 seconds] How many times has a in a to the fifth been used as a factor?

Multiple responses: five

Mr. A: How many times has a in a to the sixth been used as a factor?

Multiple responses: six

Mr. A: All together how many times has a been used as a factor?

Multiple responses: eleven times

Mr. A: That's why you add exponents. OK? Now here's a little bit of integers using algebra—

[Mr. A writes on the overhead ($3a^2$) ($-4a^3$) =]

Mr. A: —How would you do that? It's three a squared times negative 4a cubed. (2 seconds) [Tony]?

Student #4: It would be negative 12 a to the fifth power.

Mr. A: Explain.

Student #4: When you have parentheses with no sign between them you multiply. So it would be three times, it would be three times negative four is negative twelve.

Mr. A: OK. Questions? [2 seconds] Did you hear what he said? You have parentheses, no sign between them, so it implies multiply.

Student #4: And a has been used as a factor three times.

Mr. A: OK.

Student #4: And then a has been used as a factor three times so you add them.

Mr. A: Questions? [3 seconds] . . .

Mr. A then put up an example of a division problem involving variables and exponents and extended this review problem one step further. At this point the class was twenty minutes into the lesson, and they just finished discussion of the fourth problem. By this time it is obvious that Mr. A did not stick rigidly to a set plan as he directed the class based on the student responses.

This division example, the last excerpt from this portion of the lesson, served to illustrate the type of discourse and learning environment that Mr. A encouraged in the classroom. This scenario showed that students were comfortable enough to voice their opinions and to even argue their points. This excerpt picks up with a student explaining how to simplify a division problem involving variables and exponents. The student was explaining problem number seven from the review as follows:

$$\frac{12x^4\, y^2}{18x\, y^2}$$

Student #1: Can I tell you the answer?

Mr. A: All right [Eric].

Student #1: Two-thirds

Mr. A: All right, first of all what did you do then?

Student #1: Ah, ah, simplified twelve eighteenths.

Mr. A: Simplified twelve eighteenths. What's the greatest common factor for twelve eighteenths? [Misty]?

Student #2: Three

Mr. A: [Jay]

Student #3: six.

Mr. A: OK, [Misty] three would work, but you would have to do what?

Student #2: Simplify

Mr. A: Simplify again right? So, three would work, but to make it easier on us we try to get the biggest. So, he's factoring out a six right?

Student #1: And then x to the third and y. Wouldn't it be just y?

Mr. A: All right, does everybody agree that y squared divided by y squared is y?

Multiple responses: [There are many answers and there are a few saying no.]

Mr. A: Who said no?

Student #3: YES!

Mr. A: Who said no? [Jennifer]?

Student #4: [Eric]

Student #1: I did not!

Student #5: I did. I said no.

Mr. A: Why?

Student #5: Nothing is there so it's zero.

Mr. A: Can you expand this? Factor out some ys?

Student #5: Factoring out the ys would leave zero.

Mr. A: y times y and y times y. Mark out and what does that leave?

Multiple responses: y [other voices say] zero.

Mr. A: Why would it leave a y? There's nothing there.

Student #5: That's how come I said zero.

Mr. A: Now, he said subtract exponents and we get y to the zero. What did we say that anything raised to the zero power would be except for zero?

Student #6: one

Mr. A: [Mr. A demonstrates this on the overhead as he recaps the explanation.] Look, once you've used this factor and taking that factor out it's not there. So y into y goes one time, y into y goes one time, etc. etc. and one times one is one. Get that— one? [3 seconds]

After thirty-five minutes the discussion about the review problems was concluded and Mr. A changed the focus to a review of basic arithmetic with decimals to help prepare the students for the upcoming Standardized ITBS Test. He continued to use whole-group inquiry for ten more minutes and then moved to a discussion about the previous day's Hover Craft investigation. During this discussion Mr. A encouraged the students to think about science and apply their knowledge to answer the questions he had designed to evaluate the student's work on the Hover Craft activity. After a fifteen-minute whole-group discussion that was guided by the teacher's use of questions, the students were given the following homework assignment: write a paragraph explaining why the Hover Craft hovered.

For the last portion of the lesson Mr. A changed methods and had partners work together to solve problems that involved the use of patterns. After selecting a problem for the students to work he had the students work together to solve the problem and write an explanation of their thinking. While the students worked Mr. A walked around the room and encouraged them to talk to one another, think, and discuss the pattern before they tried to write their explanations. As he walked around the room he asked, things like— "Will everyone have the same explanation?" "Are you all going to see the same pattern?" "Did you write the explanation in words?"

There was a low hum of conversation in the room as the students worked with their partners to solve this problem, and as the students started to write their explanations the noise dropped off, and the room got quiet except for the sound of the electric pencil sharper and Mr. A's voice as he encouraged the students to write complete sentences and explain their thinking. After the students wrote their explanations Mr. A suggested that they read them to their partners to see if they made sense, and when everyone was about finished he extended the pattern by adding some more problems to the given sequence and asked the students to try out their theories and see if they worked. As illustrated in the previous examples Mr. A kept the students engaged as persistent problem solvers by offering hints, using guiding questions and having them share their thinking. Mr. A concluded class with five minutes of independent practice on decimal operations and assigned practice from the book on adding and subtracting decimals for additional homework.

Although no two days followed this exact same sequence of events, all of Mr. A's lessons included a variety of instructional strategies and tasks, and no matter what the task was, checking homework, introducing new material, an investigation, assessment or review, he always engaged the students in problem solving, thinking and communicating. There were five different tasks in Mr. A's typical lesson described above: one was a small-group task, one was a whole-group task and three were individual tasks. This pattern of varying instructional groups held true through all five observations as did his use of inquiry, discussion and guided questions.

Throughout all five observations Mr. A routinely selected tasks that challenged his students to think and apply their knowledge, and during each lesson observed at least two of the selected tasks were not from the textbook and involved nonroutine problem solving. Examples of some of the nontextbook based observed activities were an AIMS (Activities Integrating Mathematics and Science) Hover Craft activity, a year-long paper recycling project designed by the teacher, computer assisted instruction, and teacher-made assessment tasks both oral and written. This is not to say that the textbook did not offer challenging tasks but rather to indicate that the teacher did not rely on the textbook for all the mathematics content. Mr. A routinely used informal and formal assessment strategies during both sets of observations and consistently involved the students in self evaluation. Mr. A's classroom was a place where doing mathematics meant solving problems and explaining one's thinking or mathematical understanding.

In contrast to Mr. A's classroom the first impression from a glance into the other eight grade mathematics classroom was structure and organization. All the teaching supplies were neatly packed away in boxes, and the box labels that were visible read pattern blocks, base ten blocks, and geometric solids. Mrs. D's uncluttered desk was positioned in front of the chalkboard facing the students with an overhead projector on its cart right beside the desk. The arrangement of the individual desks occupied the majority of available space in the room. This arrangement consisted of three sections, two straight rows in the center of the room that faced the chalkboard and then two groups of desks on either side of the room that faced the center. The desks that faced the center of the room were arranged two deep with the back desks against the walls. This arrangement provided a walk-way between each section, and it easily accommodated whole-group, small-group or independent instruction.

Mrs. D's instructional approach was just as organized and structured as her classroom. Like Mr. A, Mrs. D used a variety of instructional approaches, i.e., whole-group, small-group and individual, and like Mr. A her lessons were designed with a predetermined sequence of instructional tasks, but unlike Mr. A, Mrs. D prepared guiding questions and follow-up examples in advance, and these were usually designed to provide students with all the information needed to complete the task. Mrs. D delivered her lessons in a deliberate low-key fashion, and demonstrated unlimited patience and tolerance for her students. No matter how many times she repeated the same set of directions or instructions she never raised her voice or changed her mild mannered demeanor, and, considering the instructional challenge faced by Mrs. D in her fourth block class, her ability to remain totally clam and respectful of each individual student was remarkable.

The eighth grade students were homogeneously grouped and assigned to algebra or pre-algebra and Mrs. D faced a fourth block pre-algebra class that consisted of sixteen boys and four girls who for the most part were uncooperative and not academically inclined. Mrs. D relied on positive reinforcement for classroom management, and while she consistently ignored off-task behaviors and responded in a positive manner to appropriate behaviors, the disruptive behaviors created a learning environment that made both teaching and learning difficult. Selected excerpts from Mrs. D's first observation provided examples of the learning environment, tasks, discourse and assessment typical for her fourth block mathematics class:

Mrs. D: OK, today we're going to be working with graphs. We're going to be able to identify them. Hopefully know what a graph looks like. The difference between a graph and a table or a chart. What is the difference between a graph and a table and a chart? Because we're going to be looking for graphs. How are you going to know you have a graph if you don't know the difference?
Student #1: We have a bar graph. It's different from a line graph.
Mrs. D: OK, a bar graph is different from a line graph. What's a bar graph look like?
Student #2: Bars going up.
Mrs. D: Or sometimes they'll go sideways?
Student #3: [This comment isn't clear enough to make out]
Mrs. D: Usually yes a graph will be in a square space or a rectangular space, and it will have numbers along the left-hand side and then usually something across the bottom labeled. But charts can look like that too, right? So when you're looking for a graph look for a line. Like a jagged line, or look for the bars, or some kind of—we have other kinds of graphs.
Student #4: A pie graph.
Mrs. D. All right, which is divided into sections and there are also pictographs which have little symbols in little rows. So, those are the kinds of things that you're going to be looking for. We're also going to talk about how you gather information to make a graph, or why you would want to make a graph rather than just write out in sentences the information that's given. OK? What we're going to do is look through some magazines and newspapers, mostly magazines because, I think, the newspapers are pretty well gone. But we're going to look through some magazines to find graphs. Now when you find your graph, I would like for you to find at least two graphs, and paste one on each side of the construction paper. This side and this side. [She flips the piece of construction paper in her hand over as she says this.] Those are your instructions on the board. Now some of these magazines have been looked through, so if you can't find two bar graphs, try to find at least one bar graph and then some other kind of graph. OK? You should be able to find two. After you get your graphs glued on here then I want you to make up three questions that could be answered by looking at that graph. Three questions about the graph. Do you have questions about what that involves? OK if—

Student #5: —Do you want us to answer the questions?

Mrs. D: No, you don't have to answer the questions right now. I would like you to write questions that you would be able to answer if I asked you to, or that somebody else in the class could answer by looking at the graph but you **don't** have to write the answer down. Questions? OK, when you get to the point that you need scissors, glue, construction paper, they're up here on my desk. The magazines, look at these first, and then if you don't find what you need in these then there's some more over there that they've gone through. You may work with a partner on this or you may work by yourself. If you work with a partner you need to find two graphs together, not two graphs each.

The students were quiet during the instructions, and when Mrs. D finished giving the directions the students started moving around getting materials and talking, and moving to sit with their selected work partner. As the students looked through the magazines there was some student talk about the graphs that they found, but many of the students were off task, at least one-fourth of the students were picking and laughing and joking with each other about what they found in the magazines, i.e., cars, naked babies, drinks, and women. As the students worked Mrs. D circulated around the room and talked to individuals that were working on the task to make sure that they understood what a bar graph was and that they knew what they were looking for. She chose to ignore questions about what to do if they couldn't find a bar graph, and she paid attention only to students that were working.

After 10 minutes some of the students started getting glue sticks and gluing their graphs to their papers. During this part of the activity there were whistling sounds in the background and boys wasting glue by rubbing much more than was needed on their papers and then trying to wipe it on their neighbors. One boy flipped his pencil at a girl who was walking across the floor, and after looking around to see where Mrs. D was the girl picked up the pencil and acted like she was going to throw it back. This girl spent most of the activity time walking the floor. As Mrs. D helped some students who hadn't found any graphs, boys were breaking glue sticks and acting like they were going to hit one another. A glue fight broke out at the front of the room, and Mrs. D calmly asked the two boys to sit down. Three boys discussed the beauty quotient of the girls in their magazine while two other boys fought with their scissors, and there was one boy who sat and did nothing for the entire activity. Twenty minutes after the students started looking for examples of graphs Mrs. D told them to start writing their questions. Following is an excerpt from that portion of the lesson:

Mrs. D: Folks, at this point we seem to have exhausted most of the graphs so, if you have one just go ahead and do questions about it—

Student #6: —What if you don't have any?

Mrs. D: [Bobby] said you all have one.

Student #6: He's got one. I don't.

Mrs. D: Well that's, aren't you all working together?

The students were loud, wiggly and full of conversation, but Mrs. D continued to talk with individuals who were working to try and keep the activity on track. Two students were discussing questions about their graphs, and after Mrs. D listened to their questions she asked them to write their questions on the cards that she handed to them. Thirty minutes into the activity she reminded the whole class that they should be finished looking and should be writing questions. Mrs. D continued to walk around the classroom reading students' questions, and offering assistance, but she made no evaluative comments. After spending 35 minutes on this part of the activity Mrs. D brought the class back together as a whole group for the next set of instructions which follow:

Mrs. D: At this point I would like you to stop working on the questions. I think almost everybody has at least some questions down—

[Two boys blurt out] **"NO"**

Mrs. D: —What I want you to do now is to answer some questions about graphs in general. [The class is quiet and listening to Mrs. D.] These are not about your specific graphs, but it might help you to look at the graphs that you've found to help you think about these questions about all graphs, not just the one you have. OK? Be sure and put your name on this. You may write on it. Just put your answer below the question. If there's not enough room then turn it over to the back and answer on the back.

This task consisted of seven questions about graphs in general, and the students were instructed to write the answers to the questions without talking. As the students worked on this the following events were taking place in the classroom. Two boys sat with their hands up saying we need help, and the boy beside them told them to shut-up. While Mrs. D talked with a student about how to use their graph to help them answer problem number three, there was a ball of paper being tossed around the room. One group of students was discussing farts, and another group was trying to decide who did it. A student walked into the room with a note for Mrs. D, and comments about that student's clothes abounded. After responding to the note Mrs. D turned to the rowdy bunch and asked them "Are you boys getting everything done?" As one group of students said they were done, the fragrance of the atmosphere remained the topic of discussion for the rowdy boys.

After spending twenty minutes on this part of the lesson Mrs. D asked the students to attach their questions and answers to their graph(s) and turn them in, and then she let the students take a five-minute break. Using whole-group discussion Mrs. D. introduced the third task of this lesson, making a frequency table, by asking the students where they thought the information used to make the graphs came from. The class talked about different kinds of surveys and methods of collecting data, and then Mrs. D explained how the frequency table is used to organize data for graphing. Following this explanation Mrs. D. demonstrated how to make a frequency table. She surveyed the students to find out the number of siblings they had and used these data to make a frequency table. The following excerpt illustrated how Mrs. D used guiding questions to lead students through the process of organizing and setting up a frequency table for collecting the data. This portion of the lesson picks up with Mrs. D explaining the meaning of siblings and who to count as follows:

> Mrs. D: Now if you have half brothers and sisters and step-brothers and - sisters, I'll leave that up to you if you want to count them, but just think to yourself how many siblings that you have. Then I'm going to do a survey. I'm going to ask each one of you how many siblings you have? Now what are some possible answers that you could come up with?
>
> Student #1: one, two, three, none
>
> Mrs. D: What would you think would be a pretty reasonable range?
>
> Student #2: Between two and four
>
> Mrs. D: What would possibly be the lowest number?
>
> Student #3: zero
>
> Mrs. D: And the highest?
>
> Student #4: 106.
>
> Mrs. D: So, you need to take into consideration those things when you make the chart. So, the first thing that I would write into the chart would be a list of possible responses. So there might be some people who answer zero, might be some who answer one and so on. In other words these are possible answers over here that I'm listing. OK? [Mrs. D writes these on the overhead as she explains what she is doing.] Then we'll leave it so that we can add on if we need to. In the next column we keep a count. The simplest way to keep a count is with tally marks. As I survey each person I will make a mark beside the answer that they say, and this will be my frequency chart. OK? When I call your name just tell me how many siblings.

[Mrs. D calls each student by name and records the number of siblings they have on the tally chart, and after she collects all the data she continues the explanation of how to make a frequency table.]

Mrs. D: Then what we would do is go through and determine what we would call the frequency. The frequency is how many times each answer was given. How many times was zero given as an answer?

Multiple Responses: Three

Mrs. D: Right. Basically we just count the tally marks. Now those three are easier to count when they're grouped in fives, and we won't need to include this in our chart since that response wasn't given. How would we make a graph to show this information? Now the chart is one way of doing it but sometimes a graph is a little bit more effective in showing information. Where do you put the questions on graphs? Why would you want to use a graph?

Mrs. D continued this type of guiding questioning to lead the students through the steps for turning a frequency table into a graph, and after explaining all the steps she handed out graph paper and asked the students to work independently to make a bar graph of the sibling data. Just as quickly as the supplies were handed out, hands went up into the air, and students were asking what they were suppose to do, so Mrs. D patiently went through the directions again using the overhead to illustrate what they were to do. While they worked on making their graphs Mrs. D walked around the room and helped individuals who were having trouble getting started. Mrs. D also started two versions of this graph on the chalkboard, one as a bar graph and one as a histograph. Using these two examples she explained to the class the differences between a histograph and a bar graph.

When the students finished their graphs Mrs. D collected them and handed back their graded scientific notation homework papers for the students to make corrections. Any questions about scientific notation were to be directed to the teacher, and Mrs. D spent her time helping individuals who held up their hands, but with 30 minutes of class time left the students started getting loud, wandering around the room and throwing paper again. After fifteen minutes of this Mrs. D moved back to whole group instruction to explain their homework assignment which was to make a frequency table of the number of windows in their home or apartment. The last ten minutes of class was spent with Mrs. D helping individuals with scientific notation and periodically making comments to the whole class like "Stay in your seats please." "If you don't need this time to make corrections we can do something else." "Very few of you are using your time wisely." "I asked you to put that away five minutes ago."

Like Mr. A's lessons the sequence of events was not always the same for the five lessons observed, but each lesson had common characteristics of using a variety of instructional strategies, tasks and discourse as depicted in the mathematics lesson described above. Mrs. D's March 4th lesson consisted of six different tasks, and a summary that follows the sequence of those six tasks was used to construct a snapshot view of Mrs. D's mathematics instruction. A review of previously taught material was typically the opening instructional task for each class observed. The tasks varied from written assessment to a small-group activity to, as depicted in the example above, whole-group guided questioning. Each day Mrs. D attempted to get her students involved in thinking and discussing what they already knew about the instructional objective for the day, but she took full responsibility for introducing and teaching the objective to the students. Through whole-group direct instruction Mrs. D routinely provided the students with all the necessary information, problem solving strategies and directions needed to complete the selected instructional tasks which followed.

These tasks varied from whole-group, to small-group, to independent-learning activities, and Mrs. D always monitored the students' progress and provided individual assistance as necessary. Whole-group discussion was usually used to conclude these tasks, with Mrs. D taking responsibility for summarizing what the students had learned. She then asked guiding questions to extend the lesson by connecting related objectives, and this portion of the lesson was generally followed by a performance-related task that the students completed independently and turned in for the teacher to evaluate. Usually there was a follow-up homework assignment made, and the last task was to return previously graded work for corrections. At this point in the lesson Mrs. D again provided individual assistance for students to make corrections to improve their grades. Mrs. D consistently used this type of informal assessment as well as formal written assessment to identify students who had not mastered the objectives and needed individual assistance.

Mrs. D made a daily effort to meet the students at their level and challenge them using a combination of whole-group, small-group and individual-learning activities. She provided opportunities for the students to communicate with one another and with her, but many of the students chose not to participate in the learning activities provided by Mrs. D. She consistently provided a variety of textbook and real life mathematics experiences that varied in difficulty from readiness activities to challenging investigations to routine practice. Over fifty percent of the learning tasks observed in all five lessons were based on NCTM recommended reforms, and the goals of the tasks were to get students involved in communicating and learning mathematics, but the lack of student cooperation and involvement resulted in Mrs. D doing most of the talking and the students being passive dependent-learners in a classroom where doing mathematics meant practicing the skills that the teacher taught.

Seventh Grade Teachers

Unlike the eighth grade classes, the seventh grade teachers taught heterogeneously grouped classes, and both seventh grade classes observed were similar in size and ability mix. Both teachers were responsible for covering the same set of seventh grade Standard of Learning Objectives, and they had assess to the same teaching resources. They used some of the same instructional activities and strategies, but that is where the similarities ended.

Ms. N's classroom was arranged much like Mr. A's with tables that seated two students arranged in three straight rows facing the chalkboard, and the teacher's desk which was centered in front of the chalkboard faced the students. There was an overhead projector to the right of the desk, a file cabinet in the front-left corner and a table in the back of the room that held a math-manipulative kit. This kit contained decimal blocks, fraction pieces and geometric solids. There were a couple of mathematics games, a Scrabble game and a classroom cash box stored under the table. The wall opposite the windows was covered with a long bulletin board, and Mrs. N's displayed commercially made posters about measurement. On the front wall above the chalkboard were two posters, one about problem solving strategies and one advertising that everybody's using math. Posters on the back wall of the room were about responsibility, cooperation, respect, friendship, and perseverance. The room was neat, and organized in away that made it easy for the teacher to interact with the students and effectively use a variety of instructional strategies.

Ms. N based her instructional approach on inquiry and student-centered activities, and she consistently placed an emphasis on problem solving. Her lessons were designed to help the students make connections between the skills being learned in class and real life applications. Mrs. N taught with enthusiasm, and she used her own excitement and energy to spark the students' interests, but she was also patient, tolerant and attempted to nurture and facilitate each student's growth as an independent learner. Excerpts from Mrs. N's March 18th classroom observation were selected to provide examples of these instructional practices in action.

As with all five observed mathematics classes Mrs. N started the class with a review task. Each review task was designed to get the students to reflect and summarize what they already knew about the objective being taught. On Monday, March 18, 1996, there were two review tasks used. The first one was to hand back graded practice sheets from Friday's class for students to correct and return by Tuesday. Mrs. N did not provide individual reteaching for this task, nor did she explain to the students what they did wrong. She expected the students to use the whole-class review that followed to diagnose their own mistakes and make corrections. The second task was a demonstration and whole group discussion about customary units of liquid measure. On Friday the students had made cards containing the equivalence statements about liquid measurement and this excerpt starts right after Mrs. N asked the students to get out those little cards:

> Mrs. N: . . .I have brought some containers this morning and maybe it will help you to better understand measurement. [Standing in the front of the room Mrs. N holds up a measuring cup.] What is this? What type of measuring—
>
> Multiple responses: — Liquid. A cup. [Many voices answer, but these are the two answers that are heard most.]
>
> Mrs. N: OK. How many ounces in this cup?
>
> Student #1: I don't know.
>
> Student #2: 100
>
> Student #3: Eight [There are some other answers given, but they are not clear enough to make out.]
>
> Mrs. N: There are eight ounces in a cup.
>
> Student #4: There's more than a cup there.
>
> Mrs. N: Yes, the container is larger than one cup. It will hold more than one cup, but looking at the lines. The next size of container. How much will this hold? [Mrs. N holds up a quart jar.]
>
> Multiple responses: Pint. Liter. A lot. Quart.
>
> Mrs. N: Actually we're working in cups with measurement today. We have worked with metric before, but today we're working in cup measurements. OK, how many cups in this container?
>
> Multiple responses: Four. Four cups.
>
> Mrs. N: How many ounces in one cup?
>
> Student #5: eight
>
> Mrs. N: So how many ounces would this container hold?
>
> Student #6: [Someone says 32 while she is trying to say the question and then after the question 32.
>
> Mrs. N: How many ounces would be in a gallon?
>
> Student #7: A bunch.
>
> Mrs. N: A whole bunch [she laughs and smiles as she says this]. All right what we're going to do right now, you have your cards in front of you?
>
> Multiple responses: Yeah. Yes. UN-Hun.

Mrs. N: And we have some water, and if I could have a volunteer we're going to do some conversions. OK, [Adrian].

Mrs. N had a volunteer come to the front of the room, and she asked her to pour a cup of water into a large plastic container. As the student poured the water Mrs. N asked the class how many ounces are in the large container. She encouraged the students to use their charts to answer the question. She then asked the volunteer to pour a pint of water into the larger container and again asked the class how many ounces are in a pint and how many ounces are now in the container? Mrs. N continued in this fashion until the large container was full of water, and observation data picks up with her questioning the class about the large container of water:

Mrs. N: Let's talk about how many different ways we could identify this container of water.

Student #8: 64.

Mrs. N: All right, wait just a moment. You were going to weigh what? This container contained how many ounces?

Student #8: 32.

Mrs. N: 32 OK. So, we could identify it as 32 ounces.

Student #9: Four cups.

Mrs. N: Four cups.

Student #10: One quart.

Mrs. N: And one quart. So we really can identify this container of water in what, four different ways. Talk about the four ways of identifying this one. We could call it—

Student #11: Quart

Mrs. N: We can identify it by ounces, by pints, by cups and by—

Student #11: —One quart.

Mrs. N: In fact that's what we were doing on Friday. We were converting measurement from one thing to another.

Mrs. N then held up a gallon milk jug and asked the students, "What is this?" She then went through the same type questions used in the example above to get the students to tell all the ways they could name the gallon container. After the students named all the possible relationships Mrs. N asked them if the milk container would hold four of the quart containers full of water. The students debated this, and many said it didn't look like it would hold four quarts of water. Mrs. D told then to look at their chart and see what it said. The students agreed that it said four quarts was equal to a gallon, but they still didn't believe the milk jug could hold four of the quart containers full of water. Mrs. N had a student volunteer pour four quarts of water into the gallon container, as this demonstration was completed Mrs. N asked the class how many cups he had poured in, how many ounces? etc.

A metal flower watering can held the water for this demonstration, and the students started questioning if metal can held enough water. Mrs. N in turn asked them which container was larger the gallon milk jug or the metal can. Then she asked the students to estimate how much water the metal can would hold. The class decided that it would hold about two gallons of water. They asked Mrs. N how many gallons it would hold and Mrs. N replied that she did not know.

This opening whole group demonstration piqued the students' interests which got them involved in reflecting about what they did in last Friday's class with measurement and in reviewing how to use their equivalence charts to make conversions from one unit of measure to another. As the last demonstration was completed Mrs. N set up the overhead for the next part of the lesson which was whole-group guided practice based on real life everyday objects such as a Ragu jar, and small and large diet Dr. Pepper drink containers. Mrs. N held up the Ragu jar as she turned on the overhead, and she wrote the following:

Ragu

48 oz = _______ cups

Mrs. N: This Ragu jar contains 48 ounces. How many cups would that be?

Multiple responses: Six.

Mrs. N: Tell me why this would hold six cups? What makes you think this would hold six cups?

Student #1: There are eight ounces in a cup. Eight will go into 48 six times, so there are six cups.

Mrs. N: **Very good**! All right, [Heather] said that it was six cups because she divided eight into 48. Why did she divide eight into 48?

Multiple responses: Eight ounces is a cup. Eight ounces in a cup.

Using the smaller of the two diet Dr. Pepper containers Mrs. N then asked the students how many cups were in the twenty ounce diet Dr. Pepper. This problem involved interpreting a remainder, and when one student volunteered the answer, two and 1/2 cups, Mrs. N asked why, and had the student explain how the four ounces left over were equal to half a cup. For the last guided practice problem with the large diet Dr. Pepper container Mrs. N extended the problem solving task just a little more by giving the students the measurement in quarts and ounces, two quarts and six tenths ounce, and asking the students to figure out the number of ounces.

As the students worked in groups of four on this problem Mrs. N walked around the room and looked at what the students were doing on their papers. She asked, "Is that a reasonable guess? Estimate." When one student called out an answer Mrs. N asked him to wait just a moment because she wanted everyone to calculate an answer. She then encouraged the students to think about the demonstrations they had just seen and to think about how many ounces were in the quart container. After three more minutes of work time passed Mrs. N asked the class if the diet Dr. Pepper bottle would hold two quarts? Then one group of students gave the answer, sixty-seven and six tenths ounces. Mrs. N's first response was "What do you folks think?" and there was an exchange with many students talking at one time which made it impossible to understand any one comment. At the end of this exchange Mrs. N had one student test the solution by pouring two quarts and six tenths ounces of water into the diet Dr. Pepper. Mrs. N built suspense by wondering aloud if the bottle would actually hold the amount that it claimed to hold, and the students voices rang out with "It will." or "It will not ."all around the room.

All of the students were involved in this problem solving task and all were comfortable in sharing their answers, their thinking and their conjectures. This type of guided practice with students interacting and participating in problem solving was present in all five classroom observations. Ms. N consistently planned for students to be active participants in whatever type of learning activity she provided, and she usually used hints and guiding questions to facilitate the students in their reasoning and thinking. Occasionally she resorted to telling the students the best strategy to use or the best way to solve the problem which is what happened next in this lesson.

Mrs. N set a small dry erase board up on the chalk tray with two problems written on it: (1) How many gallons of soft drinks does your group consume in a year? (2) How many tons of cereal does your group consume in a year? These are problem solving tasks that were coded as strongly supportive of reform, but the discourse that followed the introduce of these tasks eliminated the need for thinking and reasoning and turned this into a procedural-practice task. The excerpt from this portion of the lesson follows:

> Mrs. N: OK, the next thing I would like for you to do in your group. You are to do some calculations to determine the following things: How many gallons of soft drinks do you consume in one year and how many tons of cereal does your group consume in one year? The way I'd like for you to do this, the first thing I'd like for you to do is think in terms of [holds up the small diet Dr. Pepper container] this is a 20-ounce container of diet Dr. Pepper. I want you to think individually, and this will vary, how many ounces of soft drink that you would consume in one day, average? And then, after you do one day, individually, and then I'd like for you to figure how

many ounces you would consume in one week. How would we determine that? [Kendall]

Student #1: You would find how much you had to drink in one day and multiply it by seven.

Mrs. N: Why seven?

Student #1: Because there are seven days in a week.

Mrs. N: Seven days in a week. And then after we are going to determine how many ounces for one day, for one week, and then I'd like for you to multiply that by 52. Why 52?

Student #2: Number of weeks in the year.

Mrs. N: Now each person will do that individually, and then after each of you have determined how many ounces of soft drink that you would consume in a year I would like for you to find the sum for your group of three or four, and I will give you a calculator. . . .

Mrs. N went over the steps one more time, and then the groups went to work. There was lots of discussion about quarts, gallons and two liter bottles, and there was a hum in the room as the students worked on the problem. She asked them how many gallons that would be, and she asked them how they would convert the ounces to gallons. She also took the measuring cup over to the table and asked them how many ounces in a gallon. This is the one challenge that Mrs. N had left in this task, and she did use hints and guiding questions to facilitate the students thinking in solving this part of the problem. After fifteen minutes Mrs. N held up her hand and waited for the groups to respond to the signal, and then she asked the class to listen just a minute. She reviewed the steps that they were suppose to be following and the question that was asked saying, "The question I would like for you to answer is how many gallons of soft drinks does your group consume in one year?" After she reviewed, one last time, how to get the total number of ounces for each group, Mrs. N asked, "What would you divide by to determine how many gallons?" There were various answers from all over the room, and after some discussion about why four or thirty-two weren't correct one student said, "128 ounces." and numerous voices agreed. The groups went back to work, and as they finished Mrs. N discussed their results with them and then moved the group to the second problem. After twenty minutes of work time Mrs. N concluded this activity by having each group share their answers with the whole class.

Using a large box of cereal that contained two 24-ounce bags Mrs. N focused the students' attention on the second problem by asking them to estimate how many bowls of cereal would be in the 24-ounce bag. The students asked a few questions about the bag of cereal and then one student made a guess of 24. Mrs. N asked the students if they could visualize dividing the bag into 24 parts. After some discussion about what size serving this would be, some other guesses were made. Mrs. N then asked “Do you agree?” The homework assignment that she gave was to use a cereal box to determine how many ounces of cereal they eat in a day and in a week.

Mrs. N then moved the class to another small-group task: completing a study guide from the textbook about customary measurement. Mrs. N provided the following instruction for this task:

> Mrs. N: All right the next thing folks we’re going to be working on is a study guide for customary measurement, and you may work with your group members, but I would like for each person to have an answer sheet.
>
> [There are some questions about writing on the paper, and then Mrs. N continues.]
>
> Mrs. N: OK, on Friday, when you were working with customary measures, you drew pictures. I would like for you to draw a picture to represent your conversions. On this one, on this worksheet, I would like for you to draw something that would represent a pound, and if you have four pounds, then I would like for you to determine how many ounces per pound, but let’s draw pictures to go with these eighteen problems.

As the students worked on this task, Mrs. N walked around the room and talked with different groups about what they were doing. Most of the students were working busily on the task, and most of the students’ conversations were about the pictures they were using to represent their answers. Examples of some of the questions that were overhead during this interaction follow: “Do we have to draw pictures?” “Is this for a grade?” Mrs. N worked with students that needed help, and then she went back to check for understanding. After spending fifteen minutes on this task, the students became nosier and restless. At this point, Mrs. N told them to finish this practice for homework. She asked the students to be seated and join in a review about what they did today. Mrs. N used a student’s comment to start the whole-group reflection task:

> Mrs. N: [Kelly] just said to me—You know I get a little confused when I have to go from, was it gallons to pints? [The students are quiet.]
>
> Mrs. N: Could we suggest, what suggestions could we give to someone to help them remember? Could you, maybe you could draw like one container represents a gallon, and this is one gallon. How many quarts would you have in it?

Multiple responses: Four.

Mrs. N continued on with similar questions about pints and gallons, and she concluded the lesson by asking the students to complete the practice for homework.

In all the lessons observed, Mrs. N used whole-group reflection to conclude the lessons. She also demonstrated similar uses of discourse in all the lessons observed. In addition, she listened to what the students had to say and consistently used the technique of asking questions based on students comments. Mrs. N regularly supplemented *Glencoe Course 2* textbook materials with real life applications, demonstrations, or connections, and she often modified the textbooks' tasks to fit her students' needs. Routinely, Mrs. N used a variety of instructional strategies as illustrated in the typical mathematics lesson shared above. This lesson consisted of seven tasks: two were independent, two were small-group and three were whole-group. Although the order and number of each type of instructional activity varied from lesson to lesson, each type of instructional strategy was present in all five lessons observed. Ms. N regularly presented the lessons on three levels: concrete, semi-concrete and abstract. She always designed the lesson so that there was time for student each of the twenty-three students to interaction with one another as well as with her.

Mrs. N monitored the progress of her students continuously and consistently encouraged them to participate in the assigned tasks. She always wore a smile for her students, and she never raised her voice to the students. When working with the whole group, she would wait for their cooperation and then thank the students when they responded appropriately. Mrs. N handled disruptive or uncooperative students individually by either taking them into the hall to talk with them privately or by talking with them quietly at their desk. As illustrated in the last scenario shared from this lesson, Mrs. N made decisions about when to change tasks, redirect tasks, or refocus the lessons based on the students' involvement and progress in the task. Her lessons were organized and planned ahead of time, but the amount of time spent on any one part of the lesson was flexible and determined by the students' needs; therefore, Mrs. N routinely modified her lesson plans on a daily basis. Mrs. N's lessons indicated that she believed it was important for students to have conceptual and procedural knowledge of the mathematics objectives. Doing mathematics in Mrs. N's class meant participating in all kinds of problem-solving activities and discussions, listening to the teachers' instructions, and practicing skills for mastery.

The other seventh grade mathematics teacher's room was larger than Ms. N's, but not as welcoming. With its long beige walls Mrs. L's room was rather nondescript. A few posters on the back wall depicting different kinds of charts and graphs provided the only hint of color and indication that this room was used to teach math. The room was extremely neat and organized with fourteen oak tables arranged in three rows to face the chalkboard that covered the front wall of the room. Each table provided seating for two students. Mrs. L used a tall, stationary slat-topped science-lab demonstration table that was centered in the front of the room as her desk. To the right of this desk, there was an overhead projector on a cart, and to the left of the desk, there was a tall stool. This stool was positioned in front of a drafting table that served as a podium. As in the other classrooms, one of the side walls was covered with windows and the opposite wall was covered with a long bulletin board. This bulletin board was titled *Newsworthy* and displayed seventeen student written *Ted and Ed* inverse-operations stories. The room with its hardwood floor, long plaster walls, and high ceiling was so large that even with twenty-two students and two adults present, voices bounced off the walls and echoed around the room.

Mrs. L's lesson plans and instructional approach were based on mastery learning with an emphasis on drill-and-rote practice. Her lessons were designed to give the students the required information and to provide practice for mastering the skills that she taught. Mathematics instruction was usually delivered through whole-group direct instruction sessions that lasted about twenty minutes. Mrs. L moved through the textbook page by page and chapter by chapter. Additional resources were used only if they supplemented the textbook's lesson. Next to the textbook, the teacher was the sole authority in the classroom, and she demanded that each student meet her expectations or fail. Her expectations conveyed the idea that mastering one objective at a time as quickly as possible was essential to success in mathematics. This generalization of Mrs. L's mathematics instruction was illustrated in the lesson observed on Monday, March 11, 1996.

On four out of five occasions, Mrs. L opened class with a whole-group/independent review task titled *Mad Minute*. This task involved the students in writing answers to basic arithmetic problems that were either called out by the teacher or provided on a worksheet. The following excerpt illustrated how Mrs. L used the *Mad Minute* task to open class.

> Mrs. L: OK, let's get ready for *Mad Minute* warm-up. It's all multiplication. Four rows, forty.
>
> Student #1: Could we add a fifth row?
>
> Mrs. L: Let's just try to get forty in a minute first, until you guys get a minute.
>
> Student #2" [Comment that is not completely audible; it is about if this is for a grade.]
>
> Mrs. L: I know, any time I can get back to it. I told you this last half of the grading period, I'm not going to be using this too much for grading, but I do want you to be practicing.

Student #3: [There is a bad echo in this room which makes it difficult to make out much of what the students say, but there are some comments being made right now, and then the following statement is audible.] Are you going to read them today? Are we going to read our stories today?

Mrs. L: OK. Let's do *Mad Minute* first.

Student #4 [another comment that is not audible]

Mrs. L: OK, five times eight, three time nine, five times six, four time seven, eight times five, seven times three, two times. . . second row . . .[She calls one problem about every second until she completes forty problems, and the students are busy writing down the answers. The class is silent while she calls out the problems and everyone is participating.]

Mrs. L: OK, [Carol] give us the answers to the first row please.

Student #5: 40, 27, 30, 28, 40, 36, 41, 36, 18, 8.

Mrs. L called on three different students to provide the answers for the three columns of multiplication problems that were left, and then she asked, "How many of you got thirty-five up?" Approximately ten students raised their hands. One student said, "I got forty." Mrs. L responded with a comment about that not being too bad since they hadn't done this for a while. During each lesson observed, Mrs. L emphasized the importance of speed and accuracy with arithmetic skills, and during each lesson observed Mrs. L included at least one task that focused on recall of memorized facts.

The next task in this lesson was to review the previous Friday's lesson and check homework. The whole-group guided questioning was used to introduce the next part of the lesson. This illustrated how Ms. L used questions to prompt the students to recall key words of procedures previously taught. All of the lessons observed contained the type of instructional discourse depicted in the following excerpt that opens with Mrs. L questioning the students about what they did in class on Friday:

Ms L: Keep in mind that what we've been working on, if you can remember that far back to Friday. The division and multiplication of equations is a good chance for you to use that [referring to *the Mad Minute* multiplication facts drill] very quickly. Ah, the homework worksheet that you had to do though went back to something you were having a little bit of problems with before, division. The five-minute check last week addition and subtraction. Addition and subtraction of what? Anybody remember?

Student #1: [one very small voice replies] Equations

Mrs. L: OK. You were working with equations yeah. Ah, what was the property? Anyone remember? All of those same four properties that we're

going to be talking about addition, subtraction, multiplication, and division are properties of what? What do you have to do to both sides of the equation?
Student #2: [Voice is so quiet that it is not audible.]
Mrs. L: What? The same number and multiplication and division what are we doing to both sides?
Student #3: [Can not hear this comment either.]
Mrs. L: OK. Remember the example is standing between two things that weighed the same? Let's see, Oh, OK, wait a second. You all weigh the same, and if I give you each ten pounds of potatoes to hold are you still equal? So all of these properties are considered properties of equality, because if you add or subtract or multiply or divide the same number in all four operations you will still keep them equal. So, lets see how you did worksheet wise.
Student #4: It would be pretty hard to get two bags of potatoes that weighed exactly the same.
Mrs. L: I'm sure there's some deviation. . . [She then went into a discussion of scales and consumers and how all the scales should be honest weights] . . .OK. Look at your worksheet please. The first one, when they say in math, write a sentence, what does it mean?
Student #5:" A math problem.
Mrs. L: OK. you write an equation and basically they wanted you to state the inverse operation for one through six, and that reminds me. [Will] asked about your stories. I have [**Sarah** and **Brandon]** that later in the block need to try to get to WICAT, and hopefully they will **finish**, and **if they do**, we will start reading some of them tomorrow. I think some of you did really nice stories and the class would enjoy them. Ah, number one what is the inverse of what you're looking at? [She calls on a student that does not have her hand up.] [Melissa].
Student #6: Subtraction.
Mrs. L: Subtraction. So, what would you possible add to that one? [3 seconds spent looking at Melissa]
Student #6: [Student makes no comment and she looks confused.]
Mrs. L: What's your equation? Your set of steps?
Student #6: I just wrote the opposite.

Mrs. L: You just wrote the opposite? OK. Well look at it, anybody, what would you do?

All of the checking-homework task was done orally, without any written examples. The teacher continued this guided questioning approach until they reached problem fifteen. The teacher's questions were intended to lead the students to predetermined correct responses; however, Mrs. L's questions were sometimes confusing. The questions didn't always point the students in the direction intended. When this happened, she called on other students to help until the desired response was given. An exchange of questions and answers a little later in this same task illustrated this:

Mrs. L: You're looking at division. So, what is the inverse?

Student #7: Multiplication.

Mrs. L: Example, What would it be [Daniel]?

Student #8: Eight times nine equals 72.

Mrs. L: Right. How about number three? What do you think? The inverse? [Allen]?

Student #9: [coughing drowns out this voice]

Mrs. L: Um-hum and number four, [Ashley].

Student #10: Thirty-two minus 15 equals seven.

Mrs. L: Does it? You've told me 32 what? Minus 15 equals seven. Does it? No. So, what does it equal? What's the variable in that equation? Help her [Calvin], what is the variable?

Student #11: The letters.

Mrs. L: [Whitney], a variable?

Student #12: Ah, it's ah,

Mrs. L: A variable?

Student #13: W

Mrs. L: Is exactly it.

Student #11: Oh, I thought you wanted a definition.

Mrs. L: Well what is it then based on, if she says it's a W? What do you know?

Student #12: It's the number that, ah, that you don't know what it is; you got to find it.

Mrs. L was so focused on the answer that she expected to hear that she did not acknowledge a student's correct response, the letters, to her question, (What is the variable?). Even after the student explained why he made this response, Mrs. L's comment was vague and did not confirm that the variable in this case was in fact a letter. Both excerpts from this lesson provided evidence that the teacher took full responsibility for determining if a response was correct and that mathematics was provided by the textbook. This was indicated when she asked the question "When **they** say in math, write a sentence, what does it mean?"

When Mrs. L reached problem fifteen, she called out the answers for problems fifteen to twenty-four. Then she asked the students if they needed her to work any of them. One student asked a question. This was the only question that was asked by a student concerning the work. A few student questions were asked previously (e.g., Is this for a grade? Are you going to read our stories?). However, this was the first student initiated question about the lesson. The scenario that follows provided an example of discourse that depicts how Mrs. L responded to most students' questions:

Mrs. L: Any you need for me to work?

Student #1: Number twenty-one

Mrs. L: OK, what is it [Travis]? Meaning ah, how would you set it up?

Student #1: How would you set what up?

Mrs. L: The problem.

Student #1: OH.

Mrs. L: You're looking at six and four tenths a is equal to seven and two tenths. So, the inverse of that operation, so a's going to equal what?

Student #1: a?

Mrs. L: a is equal to what? The inverse is division.

Student #1: All right.

Mrs. L: Seven and two tenths divided by six and four tenth, which I am perfectly aware that you are capable of doing. [She did not work the problem on the board or overhead.] OK, number ah, the other worksheet 6-2. Your back side. Let's look at that one. That was one where the first three are for the purpose of showing you what you're doing.

Mrs. L started out with guiding questions to lead the students through the steps for solving this equation, but she quickly abandoned wait time after the questions and started answering them herself. Her last comment to the student, ". . .which I am perfectly aware that you are capable of doing" implied that the student was just pretending not to understand the problem and that this was a waste of time. At no point did she work an example on the board or the overhead for the students. Although she asked how or why after some of the problems' solutions, she was only interested in hearing what the inverse operation was rather than an explanation. Ms. L consistently focused on correct answers that placed importance on procedural knowledge.

Using the same procedure, Mrs. L had the students turn their papers over and check the back side. This was a practice to solve equations involving addition and subtraction. She used guiding questions to go over the first three problems. Then, she called out the answers for problems four through twenty-one. There was one student question about a problem that involved subtracting fractions. Mrs. L used guiding questions to take the student trough the steps for subtracting fractions. When Mrs. L finished calling out the answers she made this statement:

> Those particular problems— two things. If you did not work them for whatever reason, I want you to still go ahead and get them all done on your own. Secondly, if you ran into any major problems you need to see me and set up some time that we can go over it again one-on-one. Adding and subtracting equations [you] can't get lost at this point.

This statement indicated several things: (1) Mrs. L planned not to use any more class time reteaching this material, and she did not check for individual understanding. (2) She expected students who needed additional help to arrange a time after school to get one-on-one instruction; therefore, students who needed extra help were penalized. (3) She gave the students some responsibility for their own learning; but also took total responsibility for telling them the information they needed to know. Therefore, she encouraged students to be dependent learners.

Twenty minutes into the lesson, Mrs. L moved the class to a whole-group guided question review of solving equations that involved division. This was to prepare them for the small-group application task that she had planned. Again, Mrs. L used oral instruction only, and she used questions to lead the students through the procedure for manipulating the symbols. The next excerpt provided part of this review and indicated that not everyone was ready for this abstract level of instruction.

> Mrs. L: OK, let's review a little bit in division. You're going to do something in today's activity that you need to be able to do the division property of equality. What am I talking about? [Helen]. What's the division property of equality talking about? We had a couple of problems in that section to do that way.
>
> Student #1: I don't know.
>
> Mrs. L: You don't have any idea? Ah, you can't work those problems? Because it would surprise me greatly if you couldn't. If it's division, what's it going to be?
>
> Student #1: Multiplication?

Mrs. L: OK, that's the inverse, but if the problem is set up as a division problem, what do you actually think you can do? What [Melissa] said earlier today. What can you actually do? To both sides of the equation?

Student #1: **OH,** add and subtract

Mrs. L: Not if you're dividing.

Student #2: Multiply.

Mrs. L: Whenever the property says that you do the same thing to both sides, and you don't change it, you may change the answer but you still have, tell me—

Student #3: Equal

Mrs. L: And that's important.

Again Mrs. L's questions were designed to elicit key-word recall or specific procedural steps that should be memorized. However, often the questions did not clearly lead to the desired responses. Mrs. L's questions encouraged the students to recall what was previously said or covered in class, but her questions did not really encourage students use reasoning or to be problem solvers.

When this brief review was completed, Mrs. L told the students to open their books to page 230. She reminded them that on Friday they had worked problems four through twelve. This meant that the conceptual problems that were at the beginning of each textbook practice were skipped. Mrs. L wrote problem number 12 on the chalkboard and told the students, "Don't forget to put the steps in that some of you were having a little difficulty with." As she worked this problem on the board, she guided the students through the steps by asking questions. When this problem was completed one student said that she got 96, but she got it a different way. Mrs. L told her that she would look at her work, but that this (pointing to the board) was the way she would do this problem. She also told her that she would need to work a problem like this for the activity today. Mrs. L consistently maintained the focus on the process of manipulating abstract symbols. She encouraged the students to practice and learn the process. She did not encourage the alternative solution nor did she involve the students in reasoning about the division property of equality.

After completing two examples in this fashion, Mrs. L introduced the small-group practice activity by giving directions and then talking to the students about living in a "charge it" society. She asked the students why credit card companies did not require very large monthly payments on the balances owed. She then discussed interest and how the monthly payments are determined. The monthly minimum payment for this activity was to be determined as one-fifth of the total purchase, and Mrs. L lead the students through an example of how to calculate 1/5 of a number. The students were to go through the newspapers and select five items to purchase. They were to write down the item and its cost. After they calculated the minimum monthly payment, they were to exchange papers with one of their group members and check each other's work.

As the students used calculators and worked in their groups on this activity, Mrs. L walked around the room and reminded each group that they needed to use the formula m=b/5 (monthly payment is equal to the balance divided by five) to calculate their minimum monthly payment. After five minutes, Mrs. L told the students that they should have their five items listed and should now be working on the minimum monthly payment. As students held up their hands, Mrs. L moved to that group and explained how to get the minimum monthly payment by saying, "Take your total and divide by five." She commented on the amount of money they were going to have to make to meet their monthly payment. After ten minutes of work time, she announced that they should be "getting done." After eighteen minutes of work time, she told them their papers should now be switched with someone. She then gave the students five minutes to check each others' papers. Finally, she asked that they turn them in. Mrs. L ended class by having the students clean up the newspapers, move back to their own seats and copy down their homework assignment from the board, page 230 problems 14 - 34 even. Once the students settled down and copied their homework assignment, Mrs. L smiled and dismissed them saying, "I'll see you tomorrow."

This task was somewhat supportive of reform in that it made connections between mathematics in the classroom and the real world. The teacher planned for the students to communicate with one another as well as with her. The students were involved in evaluating their own work. Calculators were used to do the calculations, but there was little reasoning or problem solving involved in this task. Mrs. L explained how to get the total balance and how to determine the minimum monthly payment before the students ever got into their groups; therefore, the task became a routine arithmetic practice for the students to do. They were expected to do an addition problem, copy the formula, plug in the numbers, and do a division problem. The objective for this class was to learn to use the division property of equality; however, the formula used to calculate this minimum monthly payment did not require the use of this property. It also did not require the use of any of the inverse operations that they had discussed during class, since Mrs. L kept saying during the group work just divide by five.

The lesson depicted here was typical of Mrs. L's mathematics instruction for all five classes observed. She did use a combination of whole-group, small-group, and individual tasks in each lesson. The discourse used for each lesson was fairly consistent with the examples provided in this lesson. Occasionally Mrs. L asked for more detailed explanations from students. However, in general explanations of how to or summaries of what the students should know were generally handled by the teacher as illustrated in the excerpts above. The length of time spent on direct instruction, guided questioning, or student discussions varied as did the frequency of each type of discourse; although, the same instructional strategies were present in each lesson observed.

Mrs. L was in “total control” of her classroom, and she took responsibility for the students’ learning. Students were expected to follow her directions. For the most part, they did what she asked without incident. Ms. L’s main goal was to keep everyone working. She was quick to take charge of any off task behaviors. Only when her back was turned, would students attempt to talk to someone at another table or do something other than the math task at hand. These opportunities were minimal, since she only turned her back to walk from one student’s desk to another. Everything in Ms. L’s room was “managed” and was as tightly controlled as her short neatly trimmed no frills hair. She wore a smile for her students, and she cut it on and off as a form of classroom management. Mrs. L used her facial expressions to let students know when they were on target with answers, written responses, or with their behaviors. The students were proficient at reading her signals and responded accordingly.

Ms. L’s math lessons were as structured as her room and she stuck rigidly to her lesson plans. Mrs. L knew exactly what was going to happen every minute of the math lesson, and she moved the students through each part of the lesson at a rapid pace. Doing mathematics in Mrs. L’s room, meant listening to instruction, practicing arithmetic skills, and memorizing the information that was presented in order to pass a written test at the end of the chapter.

Sixth Grade Teachers

Both sixth grade classrooms were long rectangular rooms like Ms. L’s room. These rooms were different from the seventh and eighth grade classrooms, since two out of four walls were covered with long chalkboards instead of just one. Both rooms also had an off-set in one of the narrow walls that could be used for storage. When you looked into Mrs. W’s classroom, it had the appearance of a sixth-grade classroom where more than one subject was taught. There was a place value chart on the chalk tray on the side wall that went from billions to billionths. It contained the word names for the families along with the word names for each place value, the standard numeral for each place value; and its equivalent power of ten. There was also a time line of explorers on the bulletin board above the front chalkboard and underneath the chalkboard, was a set of laminated posters that related the history of measurement. The ceiling of the room was high, and this provided enough room for the overhead projector screen to be mounted in the center of the wall above the chalkboard. On the wall above the chalkboard opposite the windows, there was another time line that showed inventors up to 1983. Ms. W's desk was in the front of the room, and there was a drafting table style podium and a tall stool positioned to the right of her desk. She used the this stool to sit and write on the overhead that was positioned between her desk and the podium. There were also three filing cabinets, two tall ones and one short one, in the left-front corner of the room. Next to the short filing cabinet, there was an individual work table. Positioned in the center of the wall underneath the windows, was a small bookcase full of books and a pretzel can containing rulers. In the back of the room there was a coat rack mounted on the wall underneath the clock. There was also a cart containing books and two tape recorders. In addition, there was a bookshelf on the back wall that the students used to store their classroom textbooks. On the bottom part of the wall, there was a map of the world and a poster of numerous Garfield cats that said— "Math multiplies your chances for success." On the top half of the back wall, there was a flat representation of the world globe that identified the prime meridian, equator, North Pole, arctic circle, tropic of cancer tropic of Capricorn, and the South Pole. On the bulletin board next to the door, was a calendar of the month and above the board, a poster that read— "Life is a word problem." There was one plant, hanging next to the first window. There were also some store-made decorations on the door. The students' individual desks were arranged in five straight rows, that faced the front chalkboard, and there were five or six desks in each row.

A typical math lesson in Ms. W's room started with checking homework. Either the answers were called out by Ms. W or students worked the problems on the chalkboard. New material was introduced through whole-group direct instruction. This usually consisted of reading the example problems from the mathematics textbook with the teacher explaining how to solve the problems as she worked them on the overhead. This demonstration/lecture was followed by guided practice. The students copied about ten practice problems, as Mrs. W worked them on the overhead and asked procedural-based questions. The procedural questions were designed to lead the students through the problem solving steps. This was followed by an independent-practice assignment that the students worked on while the teacher walked around the room and monitored their work.

When Mrs. W monitored their work, she not only focused on correct answers, but also on the quality of the students' written work. She expected the students to use a sharp pencil, and to write their numbers neatly on the line. If any student's work did not meet these expectations, the student was required to start over and do it correctly. Students, who had questions, would hold up their hands, and Mrs. W would go to them individually and answer their questions. This was usually the time in which classroom disruptions would occur. Mrs. W was quick to "take charge" and assign isolation; therefore, most of the students tried to please Mrs. W by working on their math during this time. After fifteen or twenty minuets of independent practice, the rest of the page was assigned for homework. Ms. W then directed the students to put away their mathematics book and to get out their Social Studies work. Occasionally, there would be a small-group activity in place of the independent practice; however, the above description was usually the standard procedure followed by Mrs. W for teaching mathematics.

Four out of five lessons observed for Mrs. W followed the instructional routine explained above. The first lesson, observed on April 8, 1996, was selected to provide examples that support this summary of Mrs. W's typical mathematics lesson. This lesson was about multiplication and division of decimals. It began with the students taking turns reading aloud from the old *Addison-Wesley* sixth grade mathematics textbook. The first example used a problem concerning the bicentennial celebrated in 1976. Mrs. W used this information to relate what they were studying in mathematics to some of their social studies content and to review mathematics vocabulary. The following excerpt provided illustrates how Mrs. W used the scripted textbook lesson to introduce this mathematics lesson to the whole class. The dialogue begins just as a student finished reading an example problem from the book regarding the 1976 bicentennial celebration:

Mrs. W: Does anyone know what that word means, bicentennial?

[There is some chatter and giggling but no response to the question.]

Mrs. W: When America celebrated its bicentennial—

Student #1: OH, it's like when you celebrate a few years gone by like an anniversary or something.

Mrs. W: Since we celebrated in 1976?

Student #1: 200, I think.

Mrs. W: 200 years is what it is, right. 1976, and when did we declare our independence?

Student #2: 19 ah hhh—

Mrs. W: So when we did our bicentennial 200 years, it would make—estimate the product. [Kevin], what do you do to get a product? Which operation do you do?

Student #3: [The student won't answer].

Mrs. W: [Kevin], you get a product when you multiply. Yes you got it the answer in division is a quotient. OK read that paragraph.

This excerpt showed several things about the teacher's instructional strategies and discourse that was characteristic of most of the whole-group instruction that was observed.

Mrs. W used scripted lessons from the textbook. She involved the students in round-robin type activities of reading the information. Her questions were low-level recall questions that usually required only one word responses from the students. In addition, Mrs. W usually answered the questions herself and took responsibility for telling the students what they needed to know.

The next excerpt depicts the instructional practice and discourse that was present in all five lessons observed. It illustrates how Mrs. W used the examples from the textbook and guiding questions to conduct whole-group instruction. Mrs. W read aloud the next paragraph in the lesson about a fellow using a calculator to do some multiplication and division problems with decimals. The students were to use estimation to determine if the given calculator solutions were correct. Mrs. W worked the examples from the textbook on the overhead. She used guiding questions to lead the students through the process of rounding off decimals to estimate products or quotients. This portion of the classroom observation follows:

> Mrs. W: Now, he used a calculator to work the multiplication problem eight and sixty-six hundredths by six and twenty-five hundredths. What was his estimate?
>
> Several responses: Fifty-three and five tenths.
>
> Mrs. W: Fifty-three and five tenths, now, he got that answer by working it on a calculator and said, 'Well I want to make sure about that.' So, he got out a pencil and paper, and he's going to estimate it to see if the answer he got was reasonable. The way he did that was to ah, round it off, each of these numbers. What do you round off eight and sixty-six hundredths to? Closer to eight or nine?
>
> Several responses: Nine
>
> Mrs. W: Then he has six and twenty-five hundredths. Is that closer to six or seven, and then he is to multiply seven, I mean nine times six and got—
>
> Several responses: Fifty-four.
>
> Mrs. W: So, is his calculator answer approximate?
>
> Several responses: Yes
>
> Student #4: [A comment about copying this, but can't hear it all.]
>
> Mrs. W: What?
>
> Student #4: [Says another comment that is not audible.]
>
> Mrs. W: I can't hear you.
>
> Student #4: Do you want us to copy this?

Mrs. W: Oh, no. OK, the divisor is three and nine tenths, what would we round off to?

The student's question, "Do you want us to copy this?" indicated that the students were accustomed to copying examples worked by the teacher. Mrs. W continued to use the textbook examples and guided questioning to review how to round off decimals and make estimates. She went over the strategy of using compatible numbers to estimate quotients. She also reviewed the process of long division as she worked through the last two examples. Finally, Mrs. W. asked the students copy the first ten problems of the book assignment as she worked them on the overhead. The following excerpt is Mrs. W's directions for this guided-practice task:

Mrs. W: Ah, the warm-up one through ten says estimate by rounding, well let's **do** write these. Then you'll know how to record it on your paper. Go ahead and copy these. Seven and fifty-eight hundredths, I'd like for you to do these in your head, times three and twenty-four hundredths. Now, they want us to round them off so we can do basic facts, which means your multiplication table. OK, seven and fifty-eight hundredths [Mat], it is closer to seven or eight?

Mrs. W consistently focused on procedures through this lesson and involved the students in listening and copying during instruction. As she worked each problem on the overhead, Mrs. W asked the students questions that lead them through the steps for estimating products and quotients.

When they got to problem number four, Mrs. W's explanation focused on showing the students how to shorten the process for multiplication with zeros. This example illustrated Mrs. W's instructional style of teaching by telling and that she consistently placed an emphasis on procedural knowledge. The problem explained in this excerpt was 89. 36 X 38.2. Mrs. W had just finished guiding the students through rounding off the two factors:

Mrs. W: Yes. Then you multiply. People, when you multiply by zero there are some of you still multiply zero times zero is zero and zero times nine is zero, and then you do a second line four times zero is zero, and however, when you have a zero and you multiply you just bring that zero down under itself, and you're through with it. On the very same line you can go to your number in your tens column and say four times zero is zero and four times nine is thirty-six, and the answer is 3,600.

Student #1: Is that the answer?

Mrs. W: Some people, if they have a problem like that will have zeros on their paper. Just put down two zeros and go to the number. That's if you have, no matter how many zeros you have, you can do it on one line, if you want to.

Later in this same guided practice, Mrs. W talked about a short process for division. This excerpt not only illustrates Mrs. W's continued focus on procedures; but also depicts the importance she placed on the students being good listeners and practicing arithmetic skills. This excerpt begins with Mrs. W's explanation of how to estimate the quotient for problem number six, 273.5 divided by 2.8:

Mrs. W: Lots of times people use short division, and they record their numbers like that [she demonstrates on the overhead how to write the numbers], and they can do short division. It takes a lot of practice before you can do that. OK, number seven. Seven and four tenths we're going to divide that into sixty-two and ninety-six hundredths. Round off seven and four tenths to what? Closer to seven or eight?

Student #1: Seven.

Mrs. W: Need to round off sixty-two and ninety-six hundredths to a number— Now is everybody listening? — This number is going to be compatible with seven. Let's think of a number that's near sixty-two that seven goes into.

Students responses: [A students starts to answer and another student shh's him.]

Mrs. W: [Star]. In other words, close to sixty-two that seven will go into. Think of your multiplication tables. Think of your multiplication tables seven times one—

Student #1: Seven

Mrs. W: Um-hum

Student #1: Fourteen [Eighteen seconds pass with Mrs. W looking at this student.]

Mrs. W: OK. Seven goes into sixty-three? Nine. OK, number eight.

When Mrs. W waited an extremely long time for the student's answer, it put that student on the spot, and it made the teacher's unspoken point —if you don't listen and practice you won't know the answer, and knowing the answer was stressed as important in mathematics class. Mrs. W completed the ten guided-practice problems in twenty-two minutes. She then assigned the independent-written practice on page 139, problems two to thirty even and thirty-one to thirty-eight all. One of the students asked if they could work the problems on the board, and Mrs. W told them they could work the odd ones on the board. She proceeded to call out a student's name and assign them problems one, three, five, etc.

While students worked their problems at the board, they talked to one another about their problems. After all the odd problems were completed, Mrs. W asked if there were any questions about what we learned today? The students commented that this was easy, and Mrs. W told them that they always do that to you, start you out easy and then it gets hard. For fifteen minutes, the students worked on their seat work while Mrs. W walked up and down the rows looking at students' papers and talking to them about compatible numbers. Then Mrs. W closed the mathematics lesson with the following statement:

Mrs. W: Ah, people, we need, I need for you put this up and finish it for homework and listen when you come in tomorrow we're going to check your answers. That means you have to have it. Shh, Shh, Ah if you don't have a Social Studies book you need to get one. . .

All of Mrs. W's math lessons were textbook lessons, and her written lesson plans consisted of the page numbers from the book that would be covered that day. Decisions related to the lessons were which worksheet or textbook suggestions she would use for remediation, practice or enrichment. Mrs. W liked to use the retired *Addison-Wesley* textbook more than the *Glencoe Course 1* book because it was easier. She only used the new textbook as supplementary material. Her lessons were structured, and her expectations were strict. Any student who did not cooperate was placed in isolation in the room; if the student continued to be uncooperative, then the student was placed in SRC. SRC was the Student Responsibility Center where students were placed for in-school suspension. If a student was a repeat offender, or if the disruption was grievous, (e.g., fighting or talking back to the teacher), the student was suspended from school usually for one to three days. Although there wasn't an example of this during the first observation, all three methods of classroom management were observed during the five days of observations.

Since the sixth grade classes consisted of heterogeneous groups, Mrs. W had at least two math groups each day. One group had three or four students, and these students worked through the book at their own pace and received individual instruction as necessary. The other group, consisting of the remaining twenty students, reviewed the textbook lessons with the teacher. Mrs. W took the traditional approach to teaching math moving the students from one concept in the book to the next as they were ready. The amount of time spent on any one concept depended on how long it took the students to master that concept. Reteaching in the form of additional examples and written practice was provided as necessary.

Mrs. W took total responsibility for answering the students questions and telling them what they needed to know. The textbook was the mathematics authority. Nearly all of the tasks were whole-group or independent tasks. There was one partner activity observed, but generally discourse between students was discouraged. Occasionally the students talked to one another during independent practice about their work. An example of this was when the students went to the board to do the estimates of products and quotients in this lesson. However, the discourse was not planned and was not encouraged. Doing mathematics in Mrs. W's room meant listening to the teacher, copying examples, doing repetitive practice, answering recall questions, and mastering each mathematics objective as an isolated skill.

When the other sixth grade teacher talked about his goals for a math lesson, Mr. M said "I want them to think. I want them to bring out— I want them to think about what they're doing, and to be able to— I want a relaxed atmosphere to where if a question comes to their mind that deals with or is on the subject that they can feel free to come and ask me that question, and to think for themselves, and try to figure out the answers, and not just in a classroom situation but in an everyday situation." Mr. M used the textbook for his math lessons; however, he also consistently used examples from the real world to supplement the information in the textbook.

Although Mr. M's classroom resembled Mrs. W's in looking like a sixth grade classroom, his classroom arrangement was different from any of the other classrooms observed. The students' desks were metal tables that seated two students each, and each table had two open storage compartments for storing such things as papers, notebooks, pencils and pens. The desks were arranged in a rectangular shape that matched the shape of the room. There were three desks positioned in front of the chalkboard on the left wall. These desks faced the center of the room and were arranged to create a walkway that was approximately three foot wide. There were three desks across the back of the room. These students sat with their backs to the windows, there was at least a three-foot walkway between them and the back wall. A break in the rectangle to created a walkway between the back desks and the two desks on the right side of the room. There were four desks across the front of the room with a break to create a walk way between the desks on the left. The students that sat on the front row faced the chalkboard, and like the row behind them had their backs to the windows. This room arrangement created a big open space in the center of the room where Mr. M walked when he worked with individual students or when he lead discussions.

Mr. M's desk and adjoining table were adjacent to the front row of students' desks. It was positioned in front of the center of the chalkboard with approximately a three foot walk-way between his desk and the front chalkboard. He used this chalkboard for demonstrations, and working example problems. Displayed on the other chalkboard were the school's lunch and breakfast menus, a poster about "I'd get better grades but I tore all the ligaments in my head," a set of student-made construction paper cards that were hung as flaps that could be lifted up, and a banner that said—"Believe in yourself." On the bulletin board above this chalkboard, there was a cursive alphabet, and above the front bulletin board, was the same inventors time line that was in Mrs. W's room. To the left of this chalkboard, there was another bulletin board which displayed a calendar, and to the left of that was the classroom door. On the wall above the chalkboard was a set of classroom rules that follow: (1) Come prepared to learn. (2) LISTEN. (3) Be kind to others. (4) Show respect to everyone. (5) Follow class procedures and school rules. On the bulletin board in the front of the room was a *Partners in Excellence Poster*. This poster had a picture of Michael Jorden and the caption read, "You can soar to new heights by reading books." To the right-hand side of Mr. M's desk there was an overhead projector as a well as and one of the drafting-table-type podiums which he never used. It was pushed up against a small book shelf, and on the front wall to the right of the chalkboard, there was one filing cabinet. Behind the students, on the right-hand side of the room, was a study corral, an individual student desk with a chair backed into the corner. On a little desk under the TV mounted on the back wall was an Apple II GS computer and a clock. The only space that seemed cramped and crowded in the room was Mr. M's space. The rest of the room was open, and the students had easy access to each other, to the teacher and to any information displayed on the board, the overhead projector or the television.

Mr. M's approach to mathematics instruction was much like Mrs. W's with the exceptions that he incorporated students working together and he encouraged them to discussion what they were doing. Mr. M wanted the students to be able to communicate what they had learned both orally and in writing while Mrs. W focused mainly on the students' written work. Mr. M's typical math lesson began with a discussion about the objective of the day. Next he demonstrated and/or explained what the students needed to learn. Mr. M usually had the students watch and listen to three or four examples before getting the students involved in doing it themselves. For guided practice, Mr. M had the students' work with their table partners trying a few problems. Then he discussed the problems with the students and demonstrated the correct process or procedure on the board. After the guided practice, Mr. M assigned independent practice. Even though each student was expected to do the work, he encouraged them to help one another, and he spent every minute working with students who needed help. The students depended on Mr. M to validate their work. Some students required his attention more than others, but they all depended on the teacher to tell them if they were doing their problems correctly. Mr. M closed the class by summarizing what they did in class that day. He explained their homework assignment. This assignment was usually a nontraditional-type assignment requiring the students to find something in real life that matched what they were doing in class that day.

The mathematics lesson observed on April 8, 1996 was selected to provide supporting examples for this summary of a typical mathematics lesson. Mr. M opened this lesson by first checking to see that everyone had brought a protractor. He ensured that there was at least one protractor for every two students. He told the students to open their books to page 310 and to get out a clean sheet of paper. In the following classroom excerpt, the opening remarks made by Mr. M highlighted that it was the teacher's job to explain the information and the student's job it to listen and cooperate:

> M: Everybody on page 310? I need you're undivided attention please. Now everybody should be open to the right page. Everybody should be facing this way, turn around in your seats. If you would please put the pencils out of your hand, you won't need those right now. These protractors that you have in front of you put it in-between so both of you can see it, and lay it flat on your table. [The room gets quiet, and the only sound is Mr. M's voice.] All right, you have yours, and I have mine. [Some sounds of gosh how big as he holds up the demonstration size protractor.] Mine is made for the board where yours is made to use with paper. Now, I want you to listen very carefully. The first thing I want you to do is to look at this, and I will show you what it's used for. Now, on page 310 it's going to give you a couple of words, a couple of vocabulary words that we'll be going over at the same time, and you need to know what those words are, what they mean so that you will know what I'm talking about OK?

At this point, Mr. M launched into a lecture/demonstration about angles, types of angles, how to measure angles, and how to classify angles. He began the lecture by talking about the fact that angles are everywhere and used in every walk of life. He directed the students attention to the example in the book, but he did not read it to them or have them read it aloud; he talked about it. The following excerpt provides an example of the detail that Mr. M puts into his instruction:

> Mr. M: The book gives you an example of a tree being cut down, and with that tree the gentleman wants to split the logs and he uses a wedge to split the logs. Well, if you know what a wedge looks like it's large on the one end and comes down to a point and you have the lines coming, or the edges coming down to make the sharp point and you'd have to get inside with that

wedge which is what separates the log. All right those lines come down to one point, and that one point is called your vertex. Now there are angles made between the two edges of the wedge, or the rays, and the distance between the two rays, or the two edges of the wedge, they're showing forms an angle, and that angle is measured in degrees, and there's a lot of other things. A needle, is made up of angles, a ah, as it shows you there someone skipping off of a ramp. A ramp is made up of angles. You have angles everywhere. The room corners make up angles. Ah, you have, where you're boards put together, you have angles. You have angles here in the corner, here and here on this, where the two picture frames come together you've got angles. Everywhere you look, you can find angles about everywhere in every way, shape, and form. Now, we're going to be looking at three basic angles. One of those angles is called an obtuse angle, and another angle is called an acute angle, and the third is called a right angle. OK, I said that angles are measured with protractors, and this is what this is [as he holds up the large wooden board protractor] and what you've got in front of you. Now, if you look, just look at the one in front of you. All right, notice there's two sets of numbers on your protractor. There's two sets of numbers there, so you can measure the angles no matter which way they point. They may point off to the left or they many point off to the right, but you can still measure them because you have two sets of numbers. One set of numbers deals with angles that go off to the right, and angles that go off to the left use the other set of numbers. Just like when you're counting, you start counting with zero don't you, and you move your way up. You count up. All right, same thing with this. You measure an angle by always starting at zero and working you way up to a higher number. . .

As this excerpt illustrates, Mr. M took full responsibility for explaining everything the students might need to know. Mrs. M made a point to tell them everything in at least two ways, and he used visual aids to demonstrate what he was talking about whenever he could. He tried to anticipate the problems that the students might encounter as they measured angles. Then, he attempted to solve all those problems in advance. A specific example of this in the excerpt above. He explained the two sets of measures on the protractor. The students did not have to puzzle over why there were two sets of numbers on the protractor or what they might be used for.

As Mr. M continued this lecture, by discussing how to find the center of the protractor and line the protractor up on the rays of the angles. Next, he told the students that he was going to show them how to measure and draw an angle. Mr. M demonstrated the steps for drawing an angle on the board and after reviewing the term vertex, he explained how to label the angle and name it three different ways. Using the angle he had just drawn, Mr. M demonstrated placing the protractor on the angle to measure it. He asked the students to look at page 311 in their book at the definitions of the three types angles. Mr. M explained that this angle was an acute angle because its measurement was less than 90 degrees. Another excerpt from this part of the lecture depicts Mr. M's anticipation of students' problems in advance. He told them how to avoid having a problem when they measure:

> Mr. M: What if in the book that angle right there was turned around another way, it wasn't turned off to the right? Say it was turned straight down or straight up. No one says that you have to keep that book flat on your desk guys. You can turn the books around any way you want to, to get one of those rays so you can put your protractor down on that zero surface so you can measure that angle. Now if I wanted to measure, notice which way I measured awhile ago. I used this one on my zero. I can do this one the same way, and measure down and that way I can still get sixty degrees. . . . [He demonstrates putting the protector the opposite way on the angle he drew on the board and measuring from the top ray down to the bottom ray to get 60 degrees.]

After Mr. M demonstrated two different ways to measure the angle on the chalkboard, he discussed margin of error. He told students what margin of error meant as well as the reasons that their measures might differ by one to three degrees. Ten minutes after the lesson had begun, Mr. M asked the first question that he actually expected the students to answer. "Now if you'll look at your protractor, yours has something that mine doesn't have, can you see what it is?" The students volunteered answers by calling out what they noticed i.e., a line in the middle, a ruler. After a few seconds of this, Mr. M intervened and called on one student to respond. This student said, "All those little marks." Mr. M proceeded to talk about how their protractors were marked in degrees while his was just marked for every five degrees. In the excerpt that follows, he again addressed potential problems that the students might encounter when measuring the angles in the book.

> Mr. M: Now, one other thing, sometimes when you're measuring out of the book, notice how small those angles are?
>
> Student #1: I know. How you going to do that?
>
> Mr. M: Well I'm going to tell you. Those angles are small because they want to save space in the book so they can get more of the angles on there,

and give you more practice. Now, what you may have to do is this. Now let me show how I would do it on the board, and this is the way you should do it in your book. If I was looking in the book and I had to measure the angle. . . [There is a little divergent conversation about losing the chalk and Mr. M's getting senile, and then he finds the chalk and demonstrates how he can extend the ray's length.]

Mr. M: OK, let's say I was going to measure an angle, and it was only this long, OK? That's a small angle isn't it? Cause some of them in your book are about that size, and if I put this[protractor] up there it's not going to go all the way to my numbers is it?

Student #2: But you can look at it.

Student #3: No it's not.

Mr. M: I can look at it and maybe guess, but I don't want to guess so here's what I do. Here's what you do. Here's what you can do to whichever ray you're going to measure, take your straight edge, and put it on the ray you're going to measure. Now I didn't come out very straight because I drew it free hand. Let me go up here a little bit.

Student #4: We can draw in our book?

Mr. M: All right, here's what you're going to do. I know that I need to go all the way up here before I get into any of my numbers. If I line this ray up straight I can go up here, and I can put me a small mark up here. It don't have to be all the way down the page; just a small mark up there where I can see it. Now, I know that this is going to go with that. See it doesn't make any difference how long your rays are or how short your rays are because, you're not measuring the length of your ray. You're measuring the distance between the two rays, which is your degree. So now I can take this, and I can put it down here, and I can see with my angle right there how big its going to be. Now, you can do the same thing in your book. When you measure an angle, if it doesn't go up into your numbers, take your straight edge. Line one of those rays up. Make you a mark up there where you can see it. Then measure your angle. Once you get it measured, then you can erase the mark. Just make sure your using pencil. Don't use pens. All right now I want you guys to do. Look at number five in your book. You're on page, ah, 311.

At this point, thirty-two minutes into the lesson, Mr. M had the students work with their partners to measure some of the angles in the book as guided practice. As the students worked, Mr. M walked around the center of the room and continued to explain the steps for measuring an angle, and he told the students if they needed help to hold up their hands. As Mr. M observed and helped individuals measure the angle, he decided that there were a couple of other things he needed to tell the whole group. Again, these comments indicated that Mr. M was trying to eliminate problems before the students encountered them. He did all the problem solving and thinking for the students, so that all they had to do was to follow his directions and practice the procedure for measuring angles.

> Mr. M: Now, one other thing I forgot to tell you. Some of these [protractors], or most of these are clear plastic aren't they? Some have a little bit of color, but they're plastic. If you lay it down one way you'll see the numbers the right way. If you lay it down the other way, and it's so easy to do, the numbers are backwards aren't they? Don't lay it down where the numbers are backwards. Make sure you lay it where the, when you lay it face down, that those numbers are right when you you're looking at it. Now remember, you've got to have one of those rays on your vertex and laying across the zero line, and then you measure the other one.
>
> Student #1: Do you start it right there?
>
> Mr. M: Yes. That's there, and that has to be along that line, and then you're going to measure it and see where this one goes. Now, since it doesn't go all the way up you're going to have to do like I showed [Sherry]. Like this, and then you can draw a little line up here, so you can see it. Now look where the line goes and then you need to put down your answer. [Mr. M was working with one student, but he talked loud enough for the entire class to benefit from the review of the steps. Then he walked to the middle of the room to address the whole class.]
>
> Mr. M: Now, remember common sense goes a long ways here. You know if an angle is not straight up and down which is ninety degrees, if it's smaller than that there's no way it can be 120 degrees, can it? Now you do know, you can look at that angle up there without even measuring it, and you know that's not a ninety degree angle. You know it's less than ninety, right? So if you measure, and you get one that's like a hundred and twenty or a hundred and thirty, and yet it's not even half way up, you know good and well it can't be that large a number. Maybe you're looking at the wrong set of numbers.

After five minutes of working with individuals and providing additional instructions Mr. M asked if everybody had a measurement for number five. He proceeded to ask each group of students what measurement that they had. The answers varied from forty degrees to fifty-six degrees, but the majority of the answers were forty-five degrees. Mr. M went over the problem by telling them that they should have got forty-five, but with the margin of error that forty-four or forty-six would be OK. Before they went to problem number six, Mr. M showed them one more thing they could do to help them in measuring the angles. He explained that they could use the straight edge of their paper to put along one of the rays of the angle and read the measure from the edge of the paper. Mr. M had the students work again with their partners to measure the angles in problems six and seven, and the following dialogue took place:

> Mr. M: Everybody try to measure number seven and see what you get. The more practice you get with these the better off you are. [Brad] stay out of the back of the book. [The answers are in the back of the book.]
>
> Student #1: I have to see.
>
> Mr. M: NO, sir, no sir, don't want you looking back there right now.
>
> Students #1: Is it 80?
>
> Mr. M: I don't know, is it?
>
> Student #2: No, it's 25.
>
> Mr. M: Do your own measure and see what you come up with.

Mr. M encouraged everyone to practice measuring angles, but he was in charge of when the correct answer was given. He also told the students when to begin working on the next problem. For three minutes, Mr. M worked with individuals by repeating the steps for placing the protractor on the angle and reading the measure. Next, he asked for the measure of the angle in problem seven. Most of the students called out twenty-five. Mr. M responded with the following comment:

> Mr. M: Twenty-five is what you should have got. You guys are getting better at it. Now, reason, think about it. The reason I give you these, if you build something, now some of you guys, maybe even some of you girls, may be working for a contractor or an architect. . . .

The students worked to please Mr. M. He was the information giver and the mathematics authority in the room. After he gave them the correct answer for number seven, he told the class some of the reasons for learning to measure angles. His first example was the need for getting the walls square, or on center, when building a house. He continued with a detailed explanation describing how carpenters build the walls, stand them up, and then center them.

After Mr. M finished making this real life connection for the students, he assigned problems eight through twenty-three from pages 312 and 313. He instructed the students to measure each angle and write down what kind of angle it was. The students continued to work with their table partners on these problems, but many hands were raised. For fifteen minutes, Mr. M walked around the room and repeated the directions for measuring angles to individuals. Three students sat with their hands up for the whole fifteen minutes. Mr. M would go to them and show them how to do a problem, and the second he walked away, their hands went back up into the air. Mr. M went back to the chalkboard and conducted a whole-class demonstration showing how to draw a hundred fifteen degree angle. He then proceeded to help individual students with their work. There were at least three hands up in the air all the time. When two students got off task Mr. M handled it quickly with the following comment:

> Mr. M: That doesn't sound like measuring angles to me.
>
> Student #1: He lost my eraser, and he owes me—
>
> Mr. M: —that is not important right now. What's important right now is measuring angles.

Mr. M concluded the lesson by collecting his protractors and assigning homework. Following are the closing remarks for this class:

> Mr. M: All right now, here's what I want you to do. Listen to me. You can't talk and listen to me. OK. Now I know some of you don't have this and its unlikely that you're going to get done, if you don't get your own protractor. So I'm not going to make this as a homework assignment because you don't have a protractor yet. You can't do your work without it.
>
> Student #1: If we have one can we do it for homework?
>
> Mr. M: I want you to get this [holds up a protractor] first. Your homework assignment is this— number one get your own protractor. That's the first thing you need to do, get your own protractor. I want you to find three things at home that measures, three things that has [sic] an angle involved. One of them being a ninety degree angle, and one of them being a forty-five degree angle, and another one that's a thirty degree angle— anything you can find at home. In the house, outside the house, anywhere around the house, in the neighborhood, I don't care what it is, find something some object in it that has an angle in it that has a forty-five degree angle, a ninety degree angle, and a thirty degree angle. See if you can find it, that's all I'm asking for.
>
> Student #2: Do we bring it in?
>
> Mr. M: Bring it in tomorrow. Not the objects. Name of it, write down what it was, and get your own protractor please. Now go ahead and be excused.

From the beginning of class to the end of class, it was important for the students to listen to Mr. M. Although he asked very few questions that required the students to respond orally, he constantly provided information. Out of the sixty minutes spent in class, the students talked with their partners for fifteen minutes. Mr. M talked the rest of the time. This was typical of the discourse observed in all five lessons. Mr. M said that he didn't follow as strict or as rigid a lesson plan as he used to follow; however, his lessons were consistently detailed and thorough. He discussed everything with his students, and he made sure he went over every detail more than once. Mr. M regularly provided his students with an opportunity to express their questions, ideas, and/or comments. He listened to what they said and answered their questions by patiently going back over the details of the lesson.

Mr. M put all his energy into his lessons, and while he was teaching, he moved about the room asking and answering questions. He liked to keep the students on task, and he energized them with his own enthusiasm about the lesson, but he controlled everything that went on in the classroom. He told the students when to put down their pencils, when to pick up their pencils, when to write, when to talk and what to talk about. When he explained instructions and/or went over new material, he demanded the students' undivided attention. If there was a student that was not attentive, Mr. M stopped in mid-sentence to discuss the problem and then redirected the student to get with the program.

Each lesson observed involved textbook related tasks. There was a combination of whole-group, small-group, and independent instruction. The amount of time spent on direct instruction varied in each lesson observed; however at least half of each lesson observed was spent in the type of whole-group instruction illustrated in the typical lesson. The amount of time spent on small-group tasks and independent tasks varied in each lesson from ten to twenty minutes. Mr. M always planned for students to discuss what they were working on in class. He also planned time for them to be able to ask him questions individually. This individual discourse usually occurred during guided or independent practice. It consisted of the students asking Mr. M if their work was correct or help with doing the work. Mr. M rarely used hints or guided questions to prompt the students' thinking; instead, he reviewed the directions or steps provided previously in whole-group instructions. As the students worked, Mr. M responded to the students that held their hands up first. He also monitored the students' progress by doing informal assessments that focused on the students having the correct answer written on their papers. When he discovered a student who was not successful, he told or showed him or her how to answer the problem. Doing mathematics in Mr. M's room, meant listening attentively, following directions, and practicing what was taught. The students did have opportunities to talk with one another during class, but they were still dependent on the teacher to verify that their work was correct and that they were successful.

Conclusion of Snapshot View of the Classrooms

Although each classroom observed was different, anyone could have opened the door of any one of these rooms and immediately recognized the scene before their eyes as a classroom. One quick glance inside the room would have provided enough detail to determine who was the teacher and who were the students. Within one minute of observation, the classroom would have been pegged as a mathematics class. The snapshot view of mathematics education at Pleasant Middle School, showed individual mathematics instructors at every level of reform defined for this study: weakly or nonsupportive of reform, marginally supportive of reform, supportive of reform, and strongly supportive of reform. Three of the teachers observed consistently demonstrated instructional practice that was strongly supportive or supportive of reform. The other three consistently demonstrated instructional practice that was marginally supportive or nonsupportive of reform.

The eighth grade teachers and the experienced seventh grade mathematics teacher were further along in implementing reformed instructional practice than the inexperienced seventh grade mathematics teacher and the sixth grade teachers. Every teacher observed used at least one task that was supportive of reform; but, only three teachers used discourse that was supportive of reform. Three of the teachers consistently tried to provide a student-centered learning environment conducive to risk taking, problem solving and communication. All of the teachers used a combination of formal and informal assessment, but only three of the teachers demonstrated that this assessment influenced their decisions and lesson plans. The next section provides vignettes that exemplify the four defined levels of instructional reform used to determine global ratings. Following this a summary of the results of the global ratings is provided.

Level I Analysis : Identifying Instructional Reform

After establishing a snapshot view of mathematics education, the next step in Level I analysis was to document matches between the classroom instruction observed during the 1995-96 school year and the NCTM's recommended instructional reforms. The guidelines followed for this data analysis process are explained through the presentation of classroom-observation vignettes that exemplify the four ranking codes used throughout this data analysis process. Presentation of the vignettes is followed by the data analysis results for the thirty classroom observations conducted for the six teachers in this study. For each teacher, there is a summary of the initial and follow-up observations' data analysis results. This is followed by a comparison of those findings to establish the teachers' global ratings.

Vignettes Depicting the Four Overall Task Rankings

The lessons were deconstructed into separate tasks as they occurred from the opening task to the closing task of each lesson. As explained in the methodology chapter analysis of each task focused on four components of instruction: task discourse, environment, and assessment/evaluation. After each observation was analyzed and coded the lessons were then reconstructed by putting all the pieces back together to provide an overall-task rating for each part of the lesson. By using an average of these overall-task ratings, a global rating for each teacher was obtained. The global ratings were useful in making generalizations about mathematics instruction at Pleasant Middle School; however, overall-task rating provided the necessary data for creating the snapshot view of mathematics instruction. Although the overall task ratings were defined in the previous chapter with the Likert Scale for ranking tasks, the numbers did not provide the whole picture. Before providing a summary of the coded data in terms of overall-task and global ratings, a description of the four overall-task rankings (strongly supportive, supportive, marginally supportive, and weakly or nonsupportive) and a vignette that exemplifies each is provided beginning with the ranking of strongly supportive.

Mathematics Instruction Ranked as Strongly Supportive

The overall task rating was based on the sum of its four coded components, and if the sum was in the range of 13 to 16 (see Figure 3), the task was classified as strongly supportive of reform. This rating indicated that the tasks observed had significant mathematical content. The tasks also actively involved the students in problem-solving challenges as described in the last chapter. The discourse that was used supported mathematical communication included students justifying their reasoning, verifying their conclusions, making generalizations, and/or making predictions. The learning environment was supportive of risk taking, conducive to mathematical communication and student centered. Decisions regarding the direction of the lesson were made by the teacher as he or she listened to the students, and observed their progress.

Out of the one hundred thirty-nine observed tasks, fifteen were ranked as strongly supportive of reform. The following excerpt from Mrs. D's April 16th, eighth grade pre-algebra class was selected to provide an example of a task ranked as strongly supportive. Mrs. D had just finished a whole group review on solving percent problems by using ratio-and-proportion. The next task assigned was this small-group investigation that connected percent and probability:

> Mrs. D: . . . [T]oday, we're going to use what you know about probability and what you know about proportions and percents to make a prediction.

OK? What you're going to do, you're going to get a bag with twenty-four cubes in it. All you know is that there are twenty-four cubes in here, and there is a little hole in the corner where you can see one cube at a time. That's all you can see. What I want you to do is just gently shake up the bag, and turn it up and look in that corner, to see what color you see. I see a yellow one. So I will record one yellow.

Student #1: Do you have x-ray vision?

Mrs. D: No. There's a hole. For yellow, you will record one square for that sighting of the yellow cube. Then you shake it up again there's another yellow.

Student #2: [Comment that is not audible]

Mrs. D: Would you all please pay attention? You're going to need to know how to do this. The next time, I get a pink one. OK, so I'm going to record that. What you're going to do is you're going to shake up the bag, and you look at what color appears in the corner. You're going to do that a hundred times.

Student #3: Great Day!

Mrs. D: Why do you think we're doing it a hundred times?

Student #4: To find percents.

Student #5: To find each percent of each color.

Mrs. D: Because if you use a hundred, you have something that is very easily converted to a percent. Record the results on this, by shading in. If you see a green one, shade in one green block and so on. Record that until you've done it a hundred times. How are you going to know when you are through?

Student #6: You count the number of boxes.

Mrs. D: You count the number of boxes you have colored in. When you have colored in a hundred boxes all together, then you have finished your hundred trials, and then you're ready to use your information gathered to predict how many cubes you have of each color in the bag. Now each group is going to get a different mixture of cubes so you can't, you know, if you're not getting what somebody else is getting that's to be expected. Some of you will have only two colors of cubes, some of you will have three, some of you will have four, some will have five and some will have six. OK? So what we're going to do, I'm going to give you the materials. You need one recording sheet, and you need the bag with the cubes, and you can take turns looking at them, shaking the bag, and looking at them and then recording. And then after you have finished your hundred trials, look at your information and predict what you have in the bag. Do not open the bag until you are specifically told to. That's important. We're going to make predictions, and we're going to talk about our predictions, before we check them out. So don't open the bag or don't try to enlarge the hole in the bag, or whatever so you can see more than one cube at a time. You'd be surprised at how accurate you're predictions would be. OK, where you have groups of four you're working in pairs, where you have three [Mrs. D's voice is drowned out with guys fussing about who they are going to work with.]

For twenty minutes, the students worked in pairs to collect their data. As the bags rattled, they sounded like Jiffy Pop popcorn popping on a red-hot stove eye. Students' voices all around the room called out green, blue, yellow, purple, blue, yellow, green, etc. As the students collected data they asked each other questions like, "How many have you done?" and "What color did you get the most of?" When the students finished all one hundred trials, they began to make their predictions. Mrs. D went to different groups and answered questions concerning what to do if there was a remainder. After twenty minutes Mrs. D had each group share prediction of the number of each color of cubes in their bag. Mrs. D recorded their predictions on a previously prepared chart on the overhead projector. To direct whole-group discussion, Mrs. D asked questions encourage the students to explain their reasoning and problem solving strategies:

Mrs. D: How did you get your predictions?

Student #1: Looked in the bag.

Mrs. D: That's not a prediction, if you looked in the bag.

Student #2:[There are some off task conversations in the room that drowned out a second students comment.]

Mrs. D: OK, Listen please. [Matt] says that you could see which colors appeared most often and you could adjust accordingly. What did you put?

Student #3: I multiplied the percent by 24 and divided by 100.

Mrs. D: OK, you multiplied your percent by 24 and then divided by 100?

Student #3: Yeah.

Mrs. D: Does the number of squares shaded-in represent the percent that are that color?

Student #3: Yeah.

Mrs. D: Why? [Waits three seconds there are a couple of unrelated student comments that aren't clear.]

Student #3: Because there were 100 trials in all.

Mrs. D: You all are missing stuff folks. So, if that percent corresponds to the number of squares, then you can figure out of 24 what equals that percent? That's probably the most scientific way of doing it. There are other ways too, but that one probably gives you a little bit closer numbers, but not necessarily. Does anybody want to change your prediction?

Student #4: Can we look in the bag first?

Student #5: Not yet.

Mrs. D: Don't open your bags until I tell you to; we're going to do them one at a time.

Mrs. D had each group open their bag and one at a time counted the exact number of each colored cubes in their bag. As they told Mrs. D their numbers, she recorded them beside their predictions on the chart that was still displayed on the overhead projector. After all of the data were collected, Mrs. D lead a discussion about the activity by asking questions as follows:

Mrs. D: Shhh! Folks, I just want to take a minute and talk about your results here. Ah, a comparison of what your predictions were with what you actually had, and I thought your predictions were very good. In fact, sometimes I'm amazed at how close you actually get when you only see one cube at a time. What would be some of the things that might have caused the predictions to be slightly off?

Student #1: They didn't shake the bag right.

Mrs. D: Maybe you didn't shake the bag very much each time.

Student #2: Maybe we miscounted them.

Mrs. D: Maybe miscounted or even marked them the wrong color by mistake. What would be some other things that might cause it to be off?

Student #3: Counting too much.

Mrs. D; Shhh! Counting, how do you mean counting too much? [waits three seconds] Maybe not recording exactly one hundred trials? Can you think of any other ways that might have changed your predictions? How might you guess a more accurate prediction?

Student #4: Let the same person shake the bag each time, and shake it the same way.

Mrs. D: Keep your conditions the same each time?

Student #5: Double check.

Student #6: What do you mean by double check?

Student #5: Count'em twice.

Mrs. D: You could also do the test twice, couldn't you? Like you did it two hundred times or three hundred times. It might take a while, but if you were doing something that you have to be extremely accurate with, that would be a way of improving your prediction. OK, I'd like to have your sheet, if you'll have your name on those. [DeWayne] would you collect those please. Be sure if you worked with a partner that you have both persons' names on there. Take out a sheet of paper and put your heading on it.

Student #7: Oh Man! [Talking and conversations are loud as DeWayne collects the papers.]

Mrs. D: [Waits one minute and then the room gets quiet and Mrs. D starts to give directions] There will be four questions, concerning what you just did; like we did the other day. Copy each question or answer it in a complete sentence. For example on number one. The first question—What was the purpose of this experiment? Either, copy the question or write it in a complete sentence by stating the purpose of this experiment was in the way—. Somehow incorporate part of the question into your answer, so I'll know what the question was. What was the purpose of this experiment? Why did we do it? When you did it, what did you find out? Please answer these individually. This is not for group work. OK, for number two—How did you use percent in solving this problem? [30 seconds] How did you use percents in solving this problem? Number three—What other problem might be solved by this technique? In other words, could you apply it to a different situation? Last week, if you remember when we did the experiment with the lima beans, they became the fish, and we used it to count fish in the lake, and I asked you on your questions how you might be able to apply it to a different situation, and some of you said you might be able to use it to count deer in the forest, or horses on the open range, or different ways like that. Well that's what I want you to do here, but I don't want you to apply the one we did last week. I want you to apply the one we did today. How, think, how you might, some problem you might encounter, or someone might encounter that you could use this method to solve that problem. [40 seconds] What other problem might be solved using this technique?. . . . OK, for the last one—What did you learn today?

After the students completed the answers to these questions, Mrs. D had them do four application problems on the back of their paper: What is twenty-five percent of thirty-six? She encouraged the students to write a proportion to solve these percent problems, and she used leading questions to help the students get started (e.g., "How many numbers are in a proportion?" "How many numbers are given here?" "Why did you put thirty-six on the bottom?") Then she gave the second problem—What is forty percent of eighty? Not all of the students were focused on the task, but those who were working used Mrs. D's hints about the first problem and worked to complete all four problems. When they completed their work, it was turned into Mrs. D. Then she started them on the challenge problem for the week.

This task was selected as an example of tasks coded as strongly supportive of reform because it was a hands-on investigation designed to facilitate connections between procedural understanding and conceptual knowledge. It was also designed to involve students in reasoning, thinking and communicating mathematically. This task utilized a variety of methods of instruction (i.e., whole-group, small-group and individual activities). It was an investigation that involved applied problem solving. The planned discourse observed was designed to involve the students in reflecting, reasoning, making conclusions, and justifying their conclusions. Mrs. D planned and used a variety of types of discourse during this lesson. These included: students communicating with other students; students communicating with the teacher in small-group settings; students communicating with the whole group, the teacher communicating with the whole group; and individual students communicating with the teacher. There were oral and written assessments planned. One part of the written assessment involved writing explanations of how and why they used their mathematical strategies, and one question was designed to challenge the students to think and make connections. The teacher planned for the students to be actively engaged in problem solving, and she planned for them to discuss what they were learning. This class was not as cooperative or successful as Mrs. D had hoped; for, however she encouraged the students to participate and provided hints to get them back on task when necessary. Although some students were off task, the learning environment was comfortable. The students were comfortable in asking questions, making comments, and discussing their thinking.

Mathematics Instruction Ranked as Supportive

This section provides examples of instructional tasks that were ranked as supportive of reform meaning that the sum of the tasks' coded components fell in the range of 10 to 12 (see Figure 3) When the majority of coded indicators matched instructional practice identified as reform, the task component was coded as a three. In general, the tasks ranked as supportive of reform had at least one of the five characteristics that was not an indicator of reform instruction. These characteristics were: tasks was not mathematically challenging, skills were taught in isolation, the teacher told the students the best problem-solving strategy to use, alternative solutions were not encouraged, or the teacher explained why students solutions were correct or not correct. Out of the one hundred thirty-nine observed tasks, thirty-nine were ranked as supportive of reform.

Mrs. N's mathematics lessons typically contained examples of tasks that were ranked as supportive. They illustrated how the teacher removed most of the problem-solving challenge from the task, by explaining the steps the students should follow to solve the problem. The task was a small-group, problem-solving activity. In this example, students were asked to solve the following problem: (1) How many gallons of soft drinks does your group consume in a year? The task was coded as a four because it involved the students in an application-type nonroutine, problem-solving situation. The students were to work together, discuss their thinking, and then share their conclusions with the whole group.

The discourse for this task was coded as a two. The teacher planned for the students to communicate, work together, and share their conclusions; however, she used whole-group direct instruction to precisely explain what steps should be used to solve the problem. There was only one problem-solving challenge left for the students. This challenged involved their deciding how to change their answers from ounces to gallons. The environment was coded as a two/three since the students successfully worked in small groups to solve the problem. The teacher interacted with the groups to open all avenues of communication. The learning environment was supportive of risk-taking; the students and the teacher were respectful of one another. In addition, the teacher valued the students' comments and questions. She showed an interest in their thoughts and reasoning, and she encouraged the students to reason and work together to solve their problems. However, the students were treated as dependent learners because Mrs. N took responsibility for telling them the best problem-solving strategies.

The assessment/evaluation component of this task was also coded as a two/three for the following reasons. Mrs. N planned opportunities for the students to discuss their thinking with her in small-group and whole-group situations. When students asked Mrs. N questions, she responded with hints or guiding questions. She directed the lesson based on the progress that she observed the students making. Mr. N also planned a whole-group share time for students to discuss their conclusions; however, during this time she only allowed the students to give their group's answer as to the number of gallons of soft drinks their group consumed in a year. She did not ask the students if the answers were reasonable, nor did she ask them to explain or justify their answers or conclusions. Although Mrs. N had conducted some discussion regarding how the students obtained their answers as well as if the answers were reasonable with some groups, she did not have the students participate in any whole-group discussion. Instead, the focus of the whole-group discussion was solely on the groups' answers. Mrs. N. did not verify their answers as right or wrong, nor did she have the students verify their answers. She proceeded to the next problem of figuring out how many tons of cereal their group eats in a year. She planned to have the students do this problem in small groups, but after listening to the students discuss estimates of the number of servings of cereal in the large bag of cereal that she was using for a visual, she modified the assignment by changing it to a homework assignment. The students were asked to use their cereal boxes at home to determine the average number of ounces of cereal they consumed in a week, and then the next day the groups would use this information to approximate the number of tons of cereal they consume in a year. The sum for the four components of this task was ten thus, this overall-task ranking was supportive of reform.

Another example of a task ranked as supportive will illustrate some of the other types of lessons that were coded as supportive. During the class observed on March 5, 1996, Mrs. A's students spent the first half of the class in the computer lab reviewing for the upcoming ITBS test (the county's adopted standardized testing instrument) by participating in computer-assisted instruction on basic-arithmetic skills with fractions and decimals. When they returned to the classroom, Mr. A planned to check homework. This task was selected to provide another example of a task ranked as supportive. He first asked the students to get out their homework from pages 188 and 189. Then he instructed them to work with their table partners on problems one, two, three and four. Some of the students said that they had already completed these problems. Mr. A told them that their job was to explain how they got their answers. Following is the classroom observation excerpt of this task:

> Mr. A: People, once again, do we just write answers down on these problems?
>
> Multiple responses: NO
>
> Mr. A: We have to explain them. We write an explanation.
>
> Student: Oh darn, I got the answers, and now I don't know how I did it.
>
> Mr. A: That's the hard part, isn't it? I was hoping by now you would be getting good at this.
>
> Student #2: Why do you want us to explain?
>
> Mr. A: Well, I want you, I think you'll understand better if you learn how to explain them. [Student comments continue out loud about the problems, but

they are not clear, and there is whistling, and the sound of the electric pencil sharpener.]

Mr. A: Whistling stop please.

Student #3: It's a happy day.

Mr. A: [Can't understand the reply to this comment.]

Student #4: Mr. A come and see if this is right.

Mr. A: You know I won't come and tell you if it's right or not. [Andy], work.

Student #5: I'm not smart any more. I don't know how to do it.

Mr. A: Folks, I see very few of you writing—

Student #6: —I'm finished—

Mr. A: —I see you doing computation, but I don't see you writing. All right we'll work on these some more tomorrow. Let's go over two. Two. Read two. Did we go over two?

Student #7: Yeah.

Mr. A: Shh—Read three, [CJ].

Student #8: Use a pattern at the right to find [11,111 X 11,111] eleven thousand one hundred eleven times eleven thousand one hundred eleven.

Mrs. A: OK, this is one of those tricks that I showed you at the beginning of the year. How you can multiply by eleven. This continues it on. OK, lets look at it. Let me just do this here. [He writes a simpler problem on the board: 111 X 111] Without looking at the book who can give me that? Without looking at the book!

Student #9: Twelve thousand three hundred twenty-one.

Mr. A: [He writes 12321 on the board] one, two, three, two, one? See the pattern?

Student #9: Yeah.

Mr. A: Do this one: [He writes another simpler problem on the overhead 1111 X 1111 =]

Student #9: 1234321

Mr. A: Someone besides [Mark]—How did you explain it?

Student #10: I didn't explain it.

Mr. A: How would you explain this pattern to someone?

Student #11: You just add one more number each time.

Mr. A: How many digits are in the factor 111 X 111? Compare this to the digits in the pattern in the answer. [Then Mr. A writes 111111 X 111111 =] What's the answer to this problem?

A student provided the answer to the problem, and then Mr. A asked for an explanation of the pattern. The student gave the explanation as follows: "the number of digits in the factor equaled the number of digits in the counting pattern in the answer." The same procedure was used to go over problem number four which was a problem about finding how much time elapsed using a pattern. When the components of this task were coded the task itself was coded, as a three because the problems were nonroutine problem-solving challenges. There was more than one possible solution for problem number three, and there was more than one way to solve both of the problems. The students were expected to work in small groups to explain their reasoning to each other and to the teacher, but the problems were classified as pattern problems indicating that the best strategy for solving them was to look for a pattern. Teaching skills in isolation is not an indicator for reform instruction, thus the task was coded as a three.

Discourse was coded as a three also because Mr. A did not encourage alternative solutions or ideas. Although he encouraged all avenues of communication, he ultimately used guided questions to lead the students to the conclusion that he wanted. The environment was coded as a three as well, since the students were sometimes called on because they weren't listening, and often one student would dominate the whole-group discussion. Although Mr. A listened to the students, he always used guided questioning to direct the students to give the answer he expected to hear. Assessment/evaluation was coded as a three also. Mr. A planned for written and oral explanations of the patterns used for solving the problems, and he monitored the students as they worked in their groups by listening to their questions and offering hints and guiding questions. In addition he planned for the students to have time to discuss their explanations with each other, before sharing these explanations with the whole group. However, the task used word problems that required only one or two skills, and the assessment focused on the isolated skill of the students' ability to identify patterns. The sum for all of these components was twelve, thus the overall task ranking for this homework check was supportive of reform.

Mathematics Instruction Ranked as Marginally Supportive.

Out of the one hundred thirty-nine observed tasks, thirty-two tasks had overall-tasks rankings of marginally supportive of reform. This section provides examples of instructional tasks that were ranked as marginally supportive of reform, meaning that the sum of tasks' coded components fell in the range of 7 to 9 (see Figure 3). When most of the indicators of instruction did not match reform indicators, but there was at least one indicator of reform instruction present, the component was coded as a two. Therefore, tasks that were ranked as marginally supportive of reform had some aspects of reform instructions. Usually the component that was supportive of reform was the task itself, while the discourse, environment, and assessment/evaluation indicators consistently remained characteristic of instruction that was nonsupportive or marginally supportive of reform. Some of the overall tasks were ranked as marginally supportive due to at least three out of four components being coded as a two. Such is the example presented here from Mrs. L's first set of observations.

Ms. L had made a long-term assignment for the students, and it was to write a story about inverse operations and type it during their visit to the computer lab. The due date for this assignment coincided with the date for the first classroom observation. The graded assignments were returned to the students for selective oral reading during the second classroom observation. The story was to be titled: *ED & Ted's Inverse Adventure*. On the right hand side of Mrs. L's board, the requirements for this assignment were listed:

1. typing a letter on a computer
2. freezing ice cubes
3. turning on the radio
4. sweeping a floor
5. turning off a light
6. inflating a ball

The students were supposed to write a story that included all six of these items as illustrations of inverse operations. During Mrs. L's first observation, one student asked about reading these stories. Later in the lesson Mrs. L responded to that question by singling out two individuals who still needed to finish, and said that if **they** got their papers completed, then she would let them start reading their stories the next day. During the opening of the second lesson that was observed, students asked about these stories again. That exchange follows:

Student #1: Are we going to get to read our stories today?

Mrs. L: Yeah, un-hun.

Student #1: Everybody?

Mrs. L: We won't get to everyone today, but I hope that maybe we can.

Student #2: I'll read mine first. If that's OK? [Another student sits and growls during this comment.]

Mrs. L: Actually, I have them already organized the way we're going to do it, and that's because everybody goes from the top of the roll so, I'm going to start at the bottom and work up.

Student #3: Yeah, I'm last. You did that on purpose. [There are a few other comments about where the students will fall in line but they aren't clear.]

After completing the *Mad Minute* drill and the ten-problem written assessment that followed the exercise of checking homework, Mrs. L handed back the students' graded *Ted and Ed* stories. Mrs. L explained to the whole class that the stories were graded according to how many of the six required inverse operations they had correctly included in their stories. She then asked the students to come to the front of the room and stand to present their stories. At 9:30 the first student was called to start reading his story. This story was about basketball managers, and it included all six inverse operations. The second story read was not coherent. It was just a string of sentences with the six inverse operations. The class respectfully listened without comment. Mrs. L said, "thank you" or "nice job" after each student read their story, and then called the next student's name on the roll.

All of these stories were typed on the computer during the students' computer lab time. The stories varied in length from a paragraph to two pages. For fifteen minutes, the students read their stories out loud to the silent listeners. Occasionally students laughed at something that was read in one of the stories, but most of the stories were shared with indifference. The students started laying their heads on their desks, or quietly packing up their things. Six different students had shared their stories before Mrs. L announced that they would hold the rest until tomorrow. She had selected a couple of stories from another class that she wanted to share with them, and she instructed them to "pay close attention." The two stories that Mrs. L selected were lengthy, creative pieces. One was a humorous story about a new mother expecting twins, Ed and Ted, and the other story connected Ted and Ed's adventures to Social Studies. These stories were well written and made all the stories read in class seem quite inferior. Mrs. L spent twenty minutes reading the two stories to the class. When she finished, the only comments about the stories were who wrote the stories and a discussion about the source of their ideas.

This task connected mathematics to Language Arts and the concept of inverse operations to real life situations. The task also involved the application of computer technology skills. The assignment did involve some reasoning, but very little mathematics content; only repetitive practice with the concept of inverse meaning to do the opposite. Mrs. L planned for the students to share their ideas, and selected stories were displayed on the classroom bulletin board that was entitled "Noteworthy." This task was coded as a two because it was an alternative to drill-and-rote practice, and it made interdisciplinary connections, and the students were involved in writing about mathematics; however there was little or no mathematical challenge for the students.

The discourse associated with this task was also coded as a two because the students did actively participate in writing and sharing their stories orally with the whole class, but there was no discussion about the concept of inverse operations. The students were not asked to justify their examples of inverse operations, nor where they challenged to find other examples of inverse operations. The stories became repetitive and dull. The environment was also coded as a two, because the students were initially excited about getting to share their stores. They were a respectful audience, listening to the stories without disruption, but only half of the share time was used to share work from students in their class. The other half of the time was devoted to the teacher's reading of selected stories from more capable students in other classes. Ms. L had a way of subtly pointing out whose work did not meet her standards (i.e., putting only the best stories up on the bulletin board, identifying in front of the whole class the two students that were holding up the reading of the stories, and selecting examples of what she considered "good" stories from a different class' work.).

The assessment/evaluation component of this task was coded as a two because the teacher did use a rubric for evaluating the students' stories, but there was no extension or connections of this lesson to mathematical concepts. In addition, there was no discussion about what the students had learned and there was really no mathematical objective associated with the reading of the stories. When the students read their stories, Mrs. L acknowledged them with courteous statements, but she did not ask what was good about the story, what points of the story could be improved, or what were the examples of inverse operations. In fact, there was no useful feedback to the individuals or the group as a whole. The sum of the four components of this task was eight, thus, the overall task was ranked as marginally supportive of reform.

The first follow-up observation for Mr. M on May 7, 1999 is used as an example of an overall task ranked as marginally supportive due to the task being coded as supportive of reform, but the other three components not being coded as supportive of reform. In this example, Mr. M. used a whole-group demonstration with guided questioning to review finding the surface area of a three dimensional figure. He opened the lesson with a review of what they did in class the day before:

> Mr. M: All right now, [10 seconds] All right ah, [Daniel]. [The room gets silent.] My mind is a little bit ah, forgetful today, can somebody tell me what we did yesterday. Does somebody know what we did yesterday? [Christy] can you remember what we did? What did we do yesterday?

Student #!: We ah, formulas like front and back,
Mr. M: And some of those front and back—
Student #2: —And narrow top and bottom.
Mr. M: And top and bottom.
Student #3: And we had to go like from the bottom to the top, and top to the bottom, left to right. I did mine to the top. You had to times. I did times the bottom to the top.
Mr. M: What is that? What's it called?
Student #3: What?
Mr. M: [Amy], can you remember what it's called?
Student #4: Finding the area and perimeter of, of figures.
Mr. M: Ah, yeah finding the area of figures, and what's it called?
Student #5: Surface
Mr. M: What? Surface area of what?
Multiple responses: Rectangular prism. Prism.
Mr. M: Three dimensional figure. What figure did we use?
Multiple responses: A rectangle
Mr. M: A rectangular. . .
Multiple responses: Prism.
Mr. M: I want to show you something. What have I got here? [Holds up a large shoe box.]
Multiple responses: A rectangular prism.
Mr. M: Hun?
Student #6: A *Nike* box.
Mr. M: I got a *Nike* box? What else do I have besides a *Nike* box?
Multiple responses: A rectangular prism.
Mr. M: A what?
Multiple responses: **A rectangular prism**.
Mr. M: **OHHHHH** you're smart. A rectangular prism. That's what we looked at yesterday, right? [There is a little side conversation about a student who was absent that didn't see this, and then Mr. M goes on with the demonstration.] A rectangular prism. Now, I want to show you something. Remember in your book they showed you a rectangular prism, and they showed you what it looked like when you folded it out?
Multiple responses: Yes.

Mr. M: We were at ah, the length, the width and the height of a rectangular prism, right?

Multiple responses: Un hun. Yes.

Mr. M: And sometimes we're confused on what number to use, and they showed you how the box is broke down. I want to show you that. Here's what, based on what you were looking at in the book. All right, what they did was this. I'm going to take the top up. OK now, I want to show you something here. I'm going to [2 seconds] see if this will work. Now, we do something like this. Now watch. Just hang on a minute. OK, get out of there. [Students laugh as Mr. M struggles with he box lid] OK? Now, I'm going to cut this side that I ripped. Shhhhh, watch now. [Conversations are going on in the background.] Are you guys watching me, are you just wanting to argue with one another today?

Multiple responses: Watching you.

Mr. M continued cutting the edges of the shoe box and folding out the faces of the rectangular prism to provide a concrete example of the illustration in the book. After he got the box apart, he asked the students to compare it to the figure on page 404. He then reviewed how to use the length and width of each rectangular section to find the surface area of the prism. As Mr. M folded the box back into the shape of a prism, the students joked that he was killing the box because he had used his pocket knife to cut the edges. When the prism was reassembled, the students applauded. Mr. M then had the students focus on the length, the width, and the height of the prism and he talked about what to do if there was no figure illustration saying:

Mr. M: . . . You got three numbers. You got a length, a width, and a height. Each number has got to be used how many times?

Student #7: Twice.

Multiple responses: Four times.

Mr. M: Four times doesn't it? So, if you put your length and your width together twice, you put your length and your height together twice, and then you put your width and your height together twice. You got your six sides, don't you?

Student #: Yeap.

Mr. M: Then you get your area of those six sides, which means you're multiplying the length times width, and then you're adding up your product[s] which gives you the total surface. OK. Now yesterday we did on 406, three though nine, right?

Mr. M then provided an opportunity for students to ask questions, and he talked with a few individuals before they started checking their homework.

This review task was coded as a three because it connected what the students were learning with prior knowledge. In addition, it was a demonstration that addressed concrete knowledge, thus, it was an appropriate readiness activity for beginning class. It also involved the students in verbal discussion regarding what they had learned (i.e., formulas, vocabulary) and connected what they were doing in class to a real life object. The task was designed to assist students in connecting the illustrations in the book with a familiar object. It also helped them identify the length, width, and height of the prism as the lengths and widths of its six faces.

The discourse used during the demonstration was coded as a one because Mr. M used his low-level guiding questions to get the students to respond with short answer or one word recall answers. Although he did use mathematical terminology himself, he did not encourage the students to communicate using this terminology. Mr. M took responsibility for summarizing the information at the end of each question, and he often finished students' answers for them. Once Mr. M had started the actual demonstration, the discourse changed to a lecture format. The students were expected to watch and listen as he showed and told them what they needed to know. There was no problem solving involved in the demonstration. Mr. M's focus was on two things: (1) getting the students to understand how to: visualize the illustrations in the book, and (2) helping them identify and use the length, width, and height of the prism to compute the surface area. Although Mr. M did provide time for the students to ask questions, he dominated the discussion and continually asked low-level procedural questions.

The environment was coded as a two because the students were excited and interested in the demonstration. They were comfortable in giving oral responses, and many of the responses were enthusiastic whole-group responses. Mr. M praised the students when they got the answers correct, and he showed enthusiasm about the lesson. He monitored the students attentiveness and used questions to get them involved when necessary. The students were totally dependent on the teacher to explain what they needed to know, and they watched and listened carefully because they wanted to please Mr. M by learning what he wanted them to learn. There was mutual respect between the teacher and the students, and the learning environment was comfortable but teacher-centered. Everything that happened in the room revolved around what Mr. M said or did.

The assessment/evaluation component was coded as a two. Mr. M had planned this demonstration because he had noticed the day before that the students were having difficulty deciding which numbers to use and how, when computing surface area. The opening review indicated that the students had only procedural knowledge and lacked conceptual understanding, and even though Mr. M's demonstration addressed concrete knowledge, he did not pursue having the students actually find the surface area of the box. Nor did he provide any concrete materials for them to work with in order to help them develop an understanding of what surface area actually meant. Mr. M. asked rhetorical questions to check for understanding (i.e., "Right?" "OK?" "All right?" "No problems with that?") These questions were seldom answered by any students with anything other than yeah or yes. Mr. M relied on repeating the information at least twice to make sure that everyone understood, before moving to the next task. The sum of the four components of this task was eight which provided an overall task-ranking of marginally supportive of reform.

Mathematics Instruction Ranked as Weakly or Nonsupportive

Out of the one hundred thirty-nine observed tasks, fifty-two had overall tasks rankings of weakly or nonsupportive of reform. This section provides examples of instructional tasks that were ranked as weakly or nonsupportive of reform meaning that the sum of tasks' coded components fell in the range of 4 to 6 (see Figure 3). Most of these lessons were textbook-based, scripted-type lessons that followed the pattern of checking homework by calling out the answers. Then whole-group direct instruction was completed for the objective of the day by using the example problems from the book. This instruction was followed by whole group, guided practice. During this time, the teacher lead the students through the procedure required to solve the problems, while they copied the examples. Then the students were assigned the rest of the practice problems in the book as independent practice. While the students worked on these practice problems, the teacher provided individual instruction to those who did not understand the directions. Any problems that were not finished during the allotted class time, were assigned for homework. This cycle was repeated the next day. Occasionally there were variations in this pattern with assessment tasks being placed in between checking homework and direct instruction, or in place of checking homework or independent practice. The majority of all the tasks in these type lessons were coded as ones, weakly or nonsupportive of reform. Mrs. W's typical mathematics lesson, shared in the first section of this chapter, provided an example of this type of mathematics instruction.

The vignette selected to illustrate a task with an overall ranking of weakly or nonsupportive is the follow-up observation of Mrs. L on April 15, 1996. As was Mrs. L's usual practice, she started class with a *Mad Minute* warm up drill on basic facts. After a quick oral review of the rules for addition, subtraction, and multiplication of integers, Mrs. L then had the students get their worksheets to check from the previous Friday's class.

Excerpts from the homework checking exercise provide a specific example of a task that had an overall task ranking of weakly or nonsupportive of reform. This excerpt begins right after the students finished checking their answers for the *Mad Minute* drill.

> Mrs. L: Ah, get your worksheets that you did towards the end of the class on Friday. I think most of you finished them. We did subtracting integers on one side and multiplying them on the other. Before we do that, I need someone to review quickly, [Daniel], you look like a likely candidate. What are the addition rules for integers, when you're adding?
>
> [Mrs. L then used guiding questions to lead the whole class in a review of the rules for adding, subtracting and multiplying integers. Mrs. L told them that they would be starting division of integers today and they started checking their homework.]
>
> Mrs. L: OK, let's look at the subtraction one [side one of the worksheet], and, unless there's a major problem, I just think I'll quickly lead you through these. Number one, [Faith].
>
> Student #1: Fourteen.
>
> Mrs. L: Fourteen, good. Number two [Payne].
>
> Student #2: Negative five.
>
> Mrs. L: Negative five, good. [Ashley], three.
>
> Student #3: Positive two.
>
> Mrs. L: Positive two good. Ah, [Kelly] four.
>
> Student #4: Negative five.
>
> Mrs. L: Negative five. Five, [Whitney].
>
> Student #5: I don't know.
>
> Mrs. L: [Allen], help her.
>
> Student #6: Forty-eight.
>
> Mrs. L: Forty-eight. Six, [Crystal].
>
> Student #7: Negative seven.
>
> Mrs. L: Negative seven. [Chris], seven.
>
> Student #8: Twenty-three.
>
> Mrs. L: Twenty-three. [Melissa], eight.
>
> Student #9: Negative twenty-two.
>
> Mrs. L: Negative twenty-two. [James], nine.
>
> Student #10: Negative thirteen.
>
> Mrs. L: Negative thirteen? Ah, [Jason]
>
> Student #11: Ten

Student #12: Negative three.

Mrs. L: Negative what? Check your math, signs wrong [James].

Student #12: Negative three.

Mrs. L: Negative three. Eleven [Sarah].

Student #13: Positive twenty-one.

Mrs. L Positive 21. [Akem] twelve.

Student #14: Negative eight.

Mrs. L Anybody want to help?

Student #15: Thirty-six.

Mrs. L: Thirty-six ah, if you change the two signs you wind up with everything being positive so you take the sum.

Student #16: What was ten?

Mrs. L: Ten was negative thirteen. [Kelly] 13

Mrs. L continued checking all twenty-one subtraction problems in this manner. Two exchanges between the teacher and the students from problems thirteen to twenty-one are included in this example. The first one is when a student gives a wrong answer to problem fifteen and the other one occurs after they check the last problem. The exchange follows:

Student #19: Sixty-three

Mrs. L: Check you math. Your sign's right, and you are close.

Student #19: Positive sixty-four.

[After checking the last problem.]

Mrs. L: Negative sixteen. Any questions? Just about our last practice on those for a little while so, I want to be sure. How about multiplying? [Melissa].

To check the other side of the work sheet, Mrs. L continued to call students by name and have them give the answers to the multiplication problems. The exchange that took place between checking problems number seven and eleven is included because it provides data that was significant to the codes assigned to the environment and the assessment/evaluation components of this task. This excerpt begins with Mrs. L is calling upon a student to answer problem number seven:

Mrs. L: Positive sixteen. Seven, [Chirs].

Student #1: Negative one hundred thirty-five.

Mrs. L: Check your math. Ah, [Daniel].

Student #2: Negative one hundred fifty-six.

Mrs. L: Negative one hundred fifty-six. Eight, [Jennifer].

Student #3: Negative forty-two.

Mrs. L: Negative forty-two. [Kelly], nine.

Student #4: Positive seventy.

Mrs. L: Positive seventy. Ah, [Akem] number ten.

Student #5: Positive twenty-four.

Mrs. L: What did he do? [Daniel] tell him.

Student #2: [The comment made here is not audible.]

Mrs. L: No, What did you get? [Speaking to another student.]

Student #6: Negative forty-three.

Mrs. L: No, [Daniel]?

Student #2: Positive 121.

Mrs. L: Why [Daniel]?

Student #2: Ah, because the [can't understand all that is said, can only make out something times the something. . .] turns out to be negative eleven times negative eleven.

Mrs. L continued to call on students to give the answers to problems eleven through sixteen, and then, at problem seventeen, another exchange occurs that provides significant piece of data:

Mrs. L: Negative seventy-two. Getting tougher, [Daniel] how about seventeen?

Student #2: Positive sixty.

Mrs. L: Positive sixty. Number eighteen [Melissa].

[The last excerpt from this task comes after checking the last multiplication problem.]

Mrs. L: P to the second power is positive sixteen. Sixteen. Be careful of mistakes like that [adding the exponent's base instead of multiplying]. They cost you, and I know that most of you are well aware of how to do them. Are there any questions? Anybody on either one of these?

Student #1: Yes.

Mrs. L: I'm aware that you need to see me, how about Wednesday afternoon? Ah, right now, let's see, I need [Daniel] to move to where [Kelly] is. . .

This task itself, the worksheet, was coded as a one because it was a routine independent, repetitive, computation practice on subtracting and multiplying integers, and the practice was categorized by types. The purpose of the task was to provide the students practice using the rules of subtracting and multiplying integers in order to memorize them. The skills were practiced in isolation with an emphasis on the mastery of symbolic, procedural knowledge and getting the one correct solution, rather than on application, reasoning or problem solving. When checking the problems, the communication was exclusively teacher-to-student. Although there were two opportunities provided for students to ask questions about computation, they did not. The only question asked by a student was concerning the answer to a particular problem that they had checked. All of the identified task indicators were listed under mathematics instructional practices that were not indicators of reform; thus, the task was coded as weakly or nonsupportive of reform.

Discourse associated with this task was also coded as a one. All of the identified instructional indicators were categorized as nonsupportive of reform. Mrs. L engaged the students in communicating arithmetic answers, as she drafted them, in order to share their answers orally with the whole class. During the teacher directed, question-answer session, Mrs. L consistently asked low-level recall or arithmetic questions that the students answered with one or two words. She did not use questions to make any connections between the mathematics objectives being studied and real world experiences or with other mathematical concepts. Her quick pace gave the feel that it was urgent to get this material covered as quickly as possible, and her reference to the objective that they would be covering today, division of integers, indicated that covering the curriculum objectives was the goal for this task. At no time, did Mrs. L stop to go over or discuss a problem that a student had worked incorrectly.

Mrs. L was the mathematics authority in the room indicating if the students' responses were correct or incorrect, and her acceptance of the first correct responses discouraged any discussion or mathematical communication. She only encouraged one line of communication, teacher-student. When she did ask one student to help another, the request meant supply the correct answer. When she asked [Daniel] to tell a student, who had missed a problem, what he did wrong, [Daniel] provided some type of explanation that wasn't audible; it was not what Mrs. L wanted. What she really wanted was the correct answer which she immediately asked for, "No, what did you get?" Mathematical discussion was not the goal for this homework-checking task. The goal was for students to evaluate their own work based upon the number of answers that they got correct.

This excerpt was selected to show Mrs. L's practice of calling on one particular student, [Daniel], to help when the answers given were incorrect. When Mrs. L acknowledged that the problems were getting more difficult the first student she called on was [Daniel]. This was a practice that encouraged the more capable students to participate in the question-answer session, but, in turn, discouraged those students who were not as confident. All of these are indicators of instructional discourse that is not supportive of reform instruction; thus, the discourse component of this task was coded as weakly or nonsupportive of reform.

The environment associated with this task was teacher centered and teacher controlled. The teacher was the mathematics authority, and the students were depended learners striving to memorize what the teacher expected them to memorize. Her statement about careless mistakes costing them, as well as, her focus on checking answers emphasized that doing mathematics meant getting correct answers and using correct procedures. Mrs. L did not involve the students in any metacognitive learning activities, and she continually stressed that mathematics was a set of rules and symbols that the students were responsible for memorizing. She did not provide opportunities for the students to participate in problem-solving activities. Neither did she provide opportunities for them to think or communicate mathematically. Students were encouraged to direct their questions about computation to her, and when one student admitted to needing help, he or she was assigned to an after-school, tutoring session. This style of teaching did not encourage independent mathematical thinking or sharing of ideas. All of these indicators of the environment fall on the side of nonsupportive of reform; therefore, the environment component of this task was coded as a weakly or nonsupportive of reform.

The assessment/evaluation component of this task was also coded as a one. The goal of this homework-checking task was for the student to evaluate their own work by checking their answers. If a student needed additional assistance, Mrs. L made arrangements to meet them after school. This was their last practice on this for a while, and they were going on to division of integers that day. Mrs. L's instructional plans were based upon completion of the curriculum objectives and the material in the book; the students' success or lack of success were not major considerations in development of her lesson plans or in their implementation. Mrs. L strictly adhered to her plan for the day, and she methodically moved from one activity to another as scheduled, regardless of how the students were progressing. Mrs. L emphasized that it was important to be proficient with these computational skills in order for the students to pass the test at the end of the unit and be successful in eight grade mathematics. Although Mrs. L listened to the students give their arithmetic answers, she made no modifications to help the students understand why their problems were wrong or to help the students build connections or conceptual understanding. Since all of these identified indicators were characteristic of assessment/evaluation indicators that were nonsupportive of reform, the assessment/evaluation component of this task was coded as weakly or nonsupportive of reform. The sum of all four components was four thus the overall-task ranking for this homework checking task was also weakly of nonsupportive of reform.

This section provided examples of the four different overall-task rankings and explained how each task was assigned its particular ranking, but even more importantly this section provided the reader with a visual image of what each ranking's meaning. The next section of this chapter is devoted to sharing the coded results of the analyzed data. However, the numbers alone do not give the full impact of the data. The classroom vignettes depicting each overall task ranking bring to life the essence of each overall-task ranking; therefore, make the numerical data-analysis results more meaningful. The results of the analysis of the initial and follow-up observations for each teacher are presented next.

Summary of Initial and Follow-up Observations' Coded Results

The results of the coded initial and follow-up observations' data are presented for each teacher. Each teacher's summary includes the overall-task ranking for each task observed, the global rankings for each lesson, and global rankings for the initial and follow-up observations. In addition to this information, these data analysis summaries provide the following pertinent data about the observed tasks: the number of tasks that were textbook or nontextbook based; the number of individual, whole-group, small-group, and partner tasks that were used in each lesson; and the number of different types of instructional tasks used (i.e., projects, exercises, questions, constructions, applications, and problem solving.) Also, a summary chart of the analysis results for every lesson observed is provided for each teacher in the Appendix section beginning with Appendix P. In addition to all the data just described above, the chart also gives a brief description of the observed task and the codes for the four components (task, discourse, environment and assessment/evaluation) that were used to determine the overall task ranking and ultimately the global ranking.

These results are presented in the same order as the snapshot view of mathematics instruction, beginning with the eighth grade teachers. To simplify the sharing of this information, the four rankings for Tasks, Overall-Tasks, and Global Ratings are referred to as Level 1, Level 2, Level 3 and Level 4 with Level 1 representing rankings of weakly or nonsupportive, and Levels 2, 3, and 4 representing the other rankings of marginally supportive, supportive, and strongly supportive respectively.

Analysis Results of Mr. A's Initial Observations

Mr. A's first observation consisted of five tasks, and their overall-task rankings were as follows: one at Level 2, two at Level 3 and two at Level 4. This resulted in a global rating for this lesson of Level 3, supportive of reform. During the first lesson observed, Mr. A used one small-group, one whole-group and three individual-instructional tasks. Three out of five of the instructional tasks were not textbook related tasks. Mr. A used a combination of these types of instructional tasks: three question, one exercise, and one application.

For the second observation, Mr. A had a total of six tasks that had the following overall-task rankings: two at level 1, two at level 2, and two at level 3. The average for the six tasks was ten giving Mr. A a global ranking of Level 3 for the second observation. During this lesson, he again used a combination of instructional tasks (three were whole-group, one was small-group, and two were individual tasks). Two out of six of the tasks were not textbook related, and as during the first observation, Mr. A used the following variety of types of instructional tasks: two problem solving, three exercises, and one question.

The results of the third observation were similar to these, with the exception that there were fewer instructional tasks observed during this class period. This was due to the fact that Mr. A's class was scheduled to use the WICAT computer lab for the first forty minutes of class; therefore, only four different tasks were observed. Two of these had overall rankings of Level 2, and the other two had overall rankings of a Level 3 and a Level 4. Therefore, Mr. A's global ranking for this lesson was also a Level 3. As in the first two observations, Mr. A used a variety of instructional methods (one whole-group, one partner, one small-group and one individual). Two of the four tasks were not textbook-based tasks, and there were two exercises, one project and one problem-solving type task observed.

Mr. A consistently used a variety of methods of instruction during all three observations, and he regularly included whole-group, small-group, and individual instructional tasks during each lesson observed. He did not rely upon one type of task, but rather used a mixture of exercises (i.e., checking homework, worksheets, and computation assignments from the textbook), questions, applications, projects, and problem-solving-type tasks in each lesson. During the first observation, Mr. A used fifteen tasks as follows: six exercises, four questions, three problem solving, one application. and one project. A little over half, eight out of fifteen, of the tasks observed were not textbook related, and the overall task rankings were as follows: two at Level 1, two at Level 2, seven at Level 3 and four at Level 4. Eleven of the fifteen tasks observed during Mr. A's first set of classroom observations were supportive of reform; therefore, Mr. A's global ranking for the first observation was Level 3. These data are presented in Appendix P (see Tables P1, P2, and P3).

Analysis Results of Mr. A's Follow-up Observations

During the first follow-up observation, Mr. A's class was scheduled to spend the first forty minutes of the class in the computer lab; thus, during this observation there were only two tasks observed. The computer-assisted, instructional task was a nontextbook based individual exercise, and the other task was a textbook-based, whole-group, directed-questioning task to review for a unit test on Geometry. Both tasks had overall rankings of Level 3 giving the lesson had a global ranking of Level 3.

There were only four tasks observed in the second follow-up lesson, due to the unit test that took place during the first forty-five minutes of class. Of the four tasks observed, three were individual tasks, and one was a small-group task. The teacher-made, assessment task was the only task that was not provided by the textbook in this lesson. Consistent with the other observations of Mr. A, a variety of types of instructional tasks were observed as follows: one application, two exercises, and one problem solving. Two of the observed tasks had overall rankings of Level 4, one was Level 2, and one was Level 3; thus, his global ranking for this lesson was Level 3.

There were a total of six tasks observed during the follow up observation with Mr. A had the following overall task rankings were noted: two Level 2, three Level 3, and one Level 4. The types of instructional tasks used included: three exercises, one question, one application, and one problem solving. Two of the six tasks were not textbook based. Methods of instruction included the following tasks: one whole-group, four independent, and one small-group. Mr. A's global rating for the follow-up observations was Level 3. See Appendix P (Tables P4 and P5) for a summary chart of these data.

<u>A Comparisons of Mr. A's Data</u>

To verify that the mathematics instruction observed was typical of instructional practices used by the teacher the two sets of observation data were compared. The comparisons focused on the four significant points of analysis that follow: (1) types of instructional tasks used, (2) methods of instruction, (3) overall tasks ranking, and (4) sources of instructional tasks. Based upon the data provided in the two summaries above, percentages for each of these items were calculated for both the initial and follow-up observations, and a summary of the results is presented in Table 8.

Other than the number of tasks per lesson the results of the initial observations, and the follow-up observations for Mr. A were consistent. His global ranking for the follow-up observations was Level 3. This was the same as his ranking for the initial set of observations. When comparing the types of instructional tasks used in the initial observations to the types used in the follow-up observations, the results showed that exercise-type tasks were used most in both sets of observations. In the initial observations, a little less than half of the tasks were exercise tasks compared to half of the tasks being exercises in the follow-up observations. This was followed by problem solving, and questions. These were used about the same number of times in the initial observations, and then applications and projects. These results are similar to the follow-up observation except that problem solving, questions, and application were all used about the same amount of time in the follow-up observations. In addition, there was no use of projects observed in the follow-up observations. The paper recycling project observed during the initial observations was an ongoing project, but it was not active during the follow-up observations. These results indicated that Mr. A consistently used a variety of instructional tasks when teaching mathematics.

Table 8

A Comparison of Mr. A's Initial and Follow-up Observation Data

Types of Instructional Tasks	**Percent Present in Initial Observation**	**Percent Present in Follow-up Observation**
Application	7	17
Construction	0	0
Exercise	40	50
Problem Solving	20	17
Project	7	0
Question	26	16
Methods of Instructional Tasks		
Independent	40	67
Partners	7	0
Small Group	20	16
Whole Group	33	17
Sources of Instructional Tasks		
Textbook	53	67
Nontextbook	47	33
Overall Rankings of Instructional Tasks		
Level 1	13	0
Level 2	13	33
Level 3	47	50
Level 4	27	17

Mr. A used a variety of methods of instruction and during the initial observations he used independent instruction a little less than half of the time compared to a little more than half of the time during the follow-up observations. This was followed with approximately equal amounts of small-group and whole-group tasks used in both sets of observations, and partner tasks were consistently used the least. These results verify that Mr. A consistently used a variety of methods of instruction in his instructional practice.

The results of the comparison of the sources for tasks also proved to be consistent in both sets of observations. In the initial observations, about half of the tasks came from textbook materials. In the follow-up observations, a little more than half of the tasks came from textbook materials. This indicated that a little less than half of the instructional tasks used by Mr. A were taken from sources other than the textbook. Mr. A regularly regular used instructional tasks from sources other than the textbook to teach mathematics.

Although the exact percentages of overall-task rankings varied between the two observations, the results were still fairly consistent when the percentage of tasks ranked as Level 3 and 4 were compared. Three-fourths of the tasks observed in the initial observations were ranked as Level 3 or 4 compared to just a little less than three-fourths of the follow-up observations ranked as Level 3 or 4. The biggest difference was in the tasks ranked as Level 1 and Level 2. In the initial observations the tasks that were not at least supportive of reform were split between Levels 1 and 2. In the follow-up observations all of the tasks that were not at least supportive of reform were ranked as Level 2. Based upon this data, Mr. A consistently used instructional practices that were supportive of reform instruction, and his global ranking was Level 3.

Analysis Results of Mrs. D's Initial Observations.

Mrs. D's first observed lesson consisted of six tasks that had the following overall-task rankings: one at Level 1, three at Level 2, and two at Level 3. This resulted in a Global Ranking of Level 2 for Mrs. D's first lesson. Mrs. D varied the types of instructional tasks using three applications, one exercise, and two question tasks during the first observation. Five out of six of these tasks were from sources other than the textbook. The methods of instruction used during this lesson were four individual tasks, one whole-group and one small-group task.

Although half of the tasks used by Mrs. D were ranked supportive of reform, and most of her teacher directed questions were planned to encourage student thinking and reasoning, the discourse that was observed in this lesson was usually not supportive of reform. Mrs. D often took the responsibility for explaining the best problem-solving strategy to use or the necessary steps for completing the task. She usually explained the answers to the instructional questions that she posed. This type of discourse indicated that the teacher held low expectations for these students and it created an environment that resulted in students being dependent learners.

Mrs. D used a variety of oral and written assessments during this lesson; however, the pattern was usually teach the objective, practice the objective, review the objective, and then assess the students' progress. Written assessments were used to determine grades and mastery. Students that were identified as not proficient on the mathematics objective that was taught, received individual instruction and were then expected to correct their own work. Mrs. D considered the results of both oral and written assessments when making instructional decisions regarding the type of instructional task needed or when to move to the next objective. She used informal assessment strategies during class to make decisions about changing or modifying the instructional tasks.

Overall-task rankings for the second set of data varied from the first set in that there were no rankings above Level 2, however, the Global Ratings for both of these lessons were Level 2. The second lesson consisted of five tasks with the following rankings: four at Level 2 and one at Level 1. Again, over half of the instructional tasks used in this lesson were coded supportive of reform, but the discourse, environment, and assessment/evaluation components of the task were generally not supportive of reform. As in the first lesson, Mrs. D varied the methods of instruction using the following combination of tasks: two individual, one small group and two whole group. There were four exercise type tasks and one application task used during this lesson, and the application task was the only one that was not taken from the textbook materials.

During the third observation, there were two tasks with overall rankings of Level 1, and three tasks with overall rankings of Level 2. As in the first two lessons observed, Mrs. D's global ranking was Level 2. Two out of the five of the observed tasks were ranked as supportive of reform, but once again, the associated discourse, environment, and assessment/evaluation were not supportive of reform. Thus all of the overall-tasks' rankings were Level 2 or below. During the third observation, the methods of instruction varied between whole-group and independent tasks. There were two whole-group tasks and three independent tasks used. As in the previous lessons, Mrs. D varied the types of instructional tasks as follows: two applications, two exercises, and one question task. Three of these five tasks came from sources other than the textbook materials.

Although the percentages of textbook and nontextbook, related tasks varied in these lessons, Mrs. D did consistently use instructional materials from sources other than textbook materials to teach mathematics. She also used a variety of instructional tasks. Out of the sixteen tasks, six were applications, seven were exercises, and three were questions. Mrs. D used small-group instructional tasks twice during the initial observations, but the methods of instruction used most often were independent and whole-group instruction. Seven of the sixteen instructional tasks were coded as Level 3 or better, but all of Mrs. D' global rankings were Level 2, marginally supportive. Results of these coded data for all three lessons are available in Appendix Q (Tables Q1, Q2 and Q3).

Mrs. D planned lessons to get the students involved in mathematics learning, but she had to often modify her plans because of the uncooperative nature of her students. Planned discussions usually dissolved into Mrs. D telling the students the information that she expected them to practice and learn. The learning environment that Mrs. D planned did not always materialize in the classroom, but she remained patient and respectful of every student. During independent instruction, Mrs. D constantly interacted with the students by talking with them, asking them questions, and explaining or showing them how to work the problem. Although Mrs. D encouraged all the students to participate in the assigned tasks, she spent her time working with the students that showed an interest. The behavior of the off-task students created disruption in the learning environment, but Mrs. D generally encouraged the students to communicate mathematically and to be active participants in the learning process. However, the lessons usually degenerated into the teacher's telling and showing the students what they needed to do, and the students copying a procedure and practicing it.

Analysis Results of Mr. D's Follow-up Observations

The results of the first follow-up observation for Mrs. D were different than the other lessons observed in that all five tasks observed were coded at least Level 3; there were two Level 3 and three Level 4 tasks observed. Mrs. D's global ranking for this lesson was Level 4. The methods of instruction used in the follow-up observations were similar to those used by Mrs. D in the initial observations. Independent and whole-group instructional tasks were used for the majority of the instructional tasks. There was one partner task, and the other four tasks were split equally between whole-group and independent tasks. All the tasks were taken from sources other than the textbook. The types of instructional tasks used in this lesson were varied: one application, one problem solving, one exercise, and two question tasks.

This lesson was centered around a hands-on-simulation probability activity. As a result more students showed more interest during this lesson. The students participated and responded to Mrs. D's questions by giving their results, and discussed how they made their predictions. This activity made connections between probability, percents and problem solving which was characteristic of other tasks in this lesson. It was also characteristic of the tasks coded Level 3 or 4 in the initial observations. The difference was that the students cooperated and became involved in this lesson, this lead to the discourse. The environment were also supportive of reform. Although the global rankings for this lesson very were different from the initial observations' analysis results, the tasks used were similar. It was the implementation of the lesson that was different.

The second follow-up observation more closely matched the results of the initial observations. One of the tasks was ranked as Level 1. The other two were ranked Level 2. All three of the tasks were exercises. One was an independent task and two were whole-group tasks. As characteristic of Mrs. D's instructional practice, two of the tasks were taken from sources other than the textbook materials. Mrs. D's global rating for this lesson was Level 1. Charts of these data are presented in Appendix Q (see Tables Q4 and Q5).

During the follow-up observations, there were eight tasks observed with the following overall-task rankings: one Level 1, two at Level 2, two at Level 3, and three at Level 4. Methods of instruction consisted of three individual tasks, one partner task, and four whole-group tasks. Seven of the tasks were from sources other than the textbook. The types of instruction used by Mrs. D were one application, one problem solving, four exercises, and two question tasks. Since a majority of tasks observed during the follow-up sessions were ranked either Level 3 or 4, the global ranking for the follow-up observation is Level 3, supportive of reform.

Comparisons of Mr. D's Data

A comparison of the results of the coded data from Mrs. D's initial observations and the follow-up observations are presented in Table 9. Types of instructional tasks, methods of instruction, sources of instructional materials or activities, and the resulting overall-task rankings are given. The results were consistent in every area except overall-task rankings. In both sets of observations, Mrs. D varied the types of instructional tasks used during any one lesson. Excise tasks were used most often in both cases. The rest of the tasks were divided between applications, questions, and problem solving. Mrs. D also consistently used a combination of independent, whole-group and small-group tasks during both observation sessions. In both sets of observations, 80% of the tasks observed were a mixture of whole-group or independent tasks. The other 20% were small-group activities. Over fifty percent of the tasks in each set of data, were based on sources other than the textbook materials.

When the overall rankings for each set of data were compared, there were some differences. During the initial observation, over eighty percent of the overall tasks were ranked as Level 1 or 2, but in the follow-up observation over fifty percent were ranked as Level 3 or 4. As mentioned previously, this difference was due to a difference in the

Table 9.
A Comparison of Mrs. D's Initial and Follow-up Observation Data

Types of Instructional Tasks	**Percent in Initial Observation**	**Percent in Follow-up Observation**
Application	38	13
Construction	0	0
Exercise	43	50
Problem Solving	0	13
Project	0	0
Question	19	24
Methods of Instructional Tasks		
Independent	56	38
Partners	0	12
Small Group	13	0
Whole Group	31	50
Sources of Instructional Tasks		
Textbook	44	12
Nontextbook	56	88
Overall Rankings of Instructional Tasks		
Level 1	25	13
Level 2	62	25
Level 3	13	25
Level 4	0	37

discourse and learning environment between the observations. During the initial observation seven the sixteen tasks were coded as supportive of reform, but the majority of the discourse in all of those lessons was teacher dominated. Mrs. D used direct instruction with both the whole group and/or individual students to explain the procedures, strategies, or steps needed to complete the assignment. This type of discourse eliminated the need for problem-solving in the tasks, and turned the tasks into procedural practices in which the teacher checked for the correct answers. In the follow-up observation, Mrs. D sparked the students' interests and involved them in an investigation, talking to one another, and explaining or justifying their predictions. This successful lesson indicated that Mrs. D planned for the students to be active learners, but the plan was not always implemented successfully. This meant that the two sets of observations were consistent in all areas except that Mrs. D had a much better success rate during the follow-up observations. The global rankings for both sets of data were consistently Level 2; therefore, Mrs. D's global ranking was Level 2, marginally supportive of reform.

Analysis Results of Mrs. N's Initial Observations

The first lesson observed for Mrs. N consisted of seven tasks planned to provide students with different experiences with customary measurement, and the objective of the lesson was for the students to learn to convert from one unit of measure to another. Mrs. N used three different types of instructional tasks during this lesson with the following distribution: three problem-solving tasks, two exercise tasks, and two question tasks. The results of the data analysis concerning the methods of instruction revealed that the following methods of instruction were used: two independent tasks, two small-group tasks and the whole-group task. The pattern used for this lesson was independent, whole group, whole group, small group, small group, whole group and an independent homework assignment. Two of the tasks were taken from the textbook materials and five were from other sources. In this case, real-life objects were brought into the room and used for demonstration purposes as well as to create problems for the students to solve. Six of these tasks received overall rankings of Level 3 and one was ranked Level 4; thus' Mrs. N's global ranking for this first lesson was Level 3.

During the second lesson observed Mrs. N again used seven tasks, and, like the first observation, the types of tasks were distributed between problem solving, questions, and exercises. The methods of instruction varied from independent to small group to whole group. Unlike the first observation, over half of the tasks observed were exercises. There was only one question and two problem-solving tasks. The methods of instruction observed included three independent, one partner, and three whole group. The pattern was whole group, whole group, independent, whole group, partner, independent and the independent homework assignment. All seven tasks had overall rankings of Level 3. As in the first observation, Mrs. N's global ranking was Level 3.

The third lesson observed consisted of only four tasks because Mrs. N's class was scheduled to spend the last forty minutes of class working in the computer lab. During the forty minutes of time spent in the classroom, Mrs. N used three tasks again showing a combination of types of tasks and methods of instruction. There were two whole-group tasks and one partner task. The pattern of instruction was whole group, whole group, and small group followed by individual computer-assisted instruction. While in the classroom, Mrs. N used one exercise, one problem-solving, and one question task. Two of the tasks were from textbook materials and one was from another source, but all of the tasks had overall rankings of level 3. Just as in the first two observations, Mrs. N's global ranking was Level 3. Charts of Mrs. N's data for her first three observations are presented in Tables R1, R2, and R3 of Appendix R.

Analysis of each lesson showed that Mrs. N consistently used a variety of methods of instruction. During the initial observations, there were eighteen tasks. The methods of instruction observed in use were six independent, four partner or small-group, and eight whole-group tasks. Mrs. N usually started her class with two whole-group tasks, followed by one or two small-group tasks. After these experiences, she assigned independent tasks as class work or homework. On one occasion, Mrs. N did start class with an independent assessment task, but once this task was completed the pattern just described was followed. A combination of textbook and nontextbook tasks were present in all three lessons. Little more than half of the tasks were taken from sources other than the textbook. Mrs. N regularly used a mixture of the following three types of instructional tasks: exercises, problem solving, and questions, and these tasks were distributed as follows: eight were exercises, six were problem solving, and four were question tasks. The results of Mrs. N's initial observations indicated that the mathematics instructional practices observed were consistent over the three day observation period. All eighteen tasks observed were ranked as supportive of reform, and Mrs. N's global ranking for the initial observation was Level 3.

<u>Analysis Results of Mrs. N's Follow-up Observations</u>

When the follow-up observations were conducted, Mrs. N was teaching Geometry, and the objectives for the first observation were classification of angles and bisecting angles. There was little mathematical challenge in either of these lessons; however, Mrs. N did use a variety of instructional methods and various types of tasks during her instruction. During the first follow-up observation, there were seven tasks observed with the following overall rankings: one Level 2, two Level 3, and three Level 4. This resulted in global ranking of Level 3 for Mrs. N's first lesson. The methods of instruction observed during this lesson were two independent tasks, one partner task, and four whole-group tasks. Six of the seven tasks were taken from sources other than the textbook, and Mrs. N used a combination of the following types of instruction tasks: two applications, three exercises, and two question tasks. The pattern of instruction was three whole group tasks followed by a partner task, then a whole group task, with both homework and computer instruction being assigned as independent tasks. The analysis results of this observation were consistent with the results of the initial observations, but the same is not true of the second follow-up observation.

During the second lesson, Mrs. N changed from her usual pattern of whole group, whole group etc. and used whole group, independent, whole group, independent. She provided direct instruction on classifying and bisecting angles. This was followed by students' doing independent practice exercises, and then Mrs. N provided more direct instruction on the construction of an angle bisector. Finally the students practiced that skill. During this lesson, Mrs. N used four tasks with the following overall rankings: two at Level 1, one at Level 3 and one at Level 4. Mrs. N's global ranking for this lesson was Level 2. First, Mrs. N involved the whole class in the task of discussing and justifying the answers on their homework paper. She then had the students do an independent exercise for assessment purposes. The next two tasks in the lesson were teacher-centered. The teacher talked and demonstrated while the students listened as passive learners. There was no real mathematical challenge offered with the task of constructing angle bisectors; students were expected to complete a construction of an angle bisector on scrap paper. During this lesson, Mrs. N limited her methods of instruction to an equal mix of independent and whole-group tasks. The types of tasks used were also split equally between exercises and questions. These data are presented in Tables R4, and R5 (see Appendix R).

Although Mrs. N had a lower global rating for the second follow-up observation, the average of the eleven tasks' overall rankings resulted in a global ranking of Level 3 for the follow-up observations. Out of the eleven tasks observed in the follow-up observations, eight of these were split between the overall-task rankings of Levels 3 and 4. Six of the eleven tasks were whole group. The remaining tasks, four independent, and one was a partner task. Seven of the observed tasks were taken from sources other than the textbook. Mrs. N used three different types of instructional tasks application, question and exercise. During the follow-up observation, Mrs. N used two applications, five exercises, and four question-type tasks.

Comparison of Mrs. N's Data

The majority of the types of tasks as well as the methods of instruction observed during the follow-up observation were consistent with the instructional practices exhibited in the initial observation. A comparison of the percentage of tasks in each category for the initial and follow-up observations is presented in Table 10. Based upon these data, a comparison of the types of instructional tasks used during the initial and the follow-up observations revealed the following similarities. Mrs. N used three different tasks during both observations. Almost half of the tasks used during each observation were exercise tasks, and one-third of them were problem-solving or question tasks. These results indicated that Mrs. N consistently made it a practice to use various types of instructional tasks to teach mathematics. Another characteristic common to both sets of data was that over half of the tasks in each observation were taken from sources other than the textbook. This indicated that Mrs. N did not use rote lessons from the textbook as a regular part of her instructional practice. In both observations, Mrs. N used at least three different methods of instruction. The results for both sets of data indicated that about half of the tasks were whole-group tasks and one-third of the tasks were independent. The remainder of the tasks were small group.

Table 10

A Comparison of Mrs. N's Initial and follow-up Observation Data

Types of Instructional Tasks	**Percent in Initial Observation**	**Percent in Follow-up Observation**
Application	0	19
Construction	0	0
Exercise	45	45
Problem Solving	33	0
Project	0	0
Question	22	36
Methods of Instructional Tasks		
Independent	33	36
Partners	11	9
Small Group	11	0
Whole Group	45	55
Sources of Instructional Tasks		
Textbook	45	36
Nontextbook	55	64
Overall Rankings of Instructional Tasks		
Level 1	0	18
Level 2	0	10
Level 3	94	36
Level 4	6	36

The overall-task rankings was the only category in which the data showed a slight difference. One hundred percent of the initial-observation tasks were coded as at least supportive of reform compared to about 80% of the follow-up observations' tasks ranked supportive of reform. Although the numbers differed, they both indicated that over 75% of the instructional tasks observed during the follow-up observations matched the instructional tasks in the initial observation. This was a good indication that the instructional practices observed were typical of Mrs. N's mathematics teaching. Mrs. N's global ranking for each of the observations was Level 3; therefore, Mrs. N's mathematics instruction received an overall global ranking of Level 3.

Analysis Results of Mrs. L's Initial Observations

The first set of data, collected during Mrs. L's initial observation, revealed that only one out of five instructional tasks was ranked as supportive of reform, and all five overall-task rankings were Level 2 or 1. During the first observation, Mrs. L used three whole-group tasks, one small-group task, and one independent task. Three out of five tasks were from the textbook, but only one of the two tasks that were taken from sources other than the textbook was ranked supportive of reform. Mrs. L used three types of instructional tasks to teach this mathematics lesson: three of the five tasks were exercises. One was a question task and an the other one was an application task.

Although Mrs. L did vary her methods of instruction and the types of instructional tasks, the discourse, and environment were not supportive of independent learning. Mrs. L was in total charge and assumed total responsibility for telling the students what they needed to know. Mrs. L's mathematics instruction followed a rigid plan. Class started with a short drill for review, and then the students checked the answers on their homework papers. Whole-group instruction and guided practice usually followed the homework check, and guided practice was followed by small-group or independent-practice tasks. Sometimes assessment tasks were assigned after homework checking. At times, there was no new material covered; however, was introduced this was Mrs. L's typical pattern of mathematics instruction. With three tasks with overall rankings of Level 2 to two tasks with overall rankings of Level 1, Mrs. L's global ranking for this lesson by description, was Level 2, but the average of the five overall-task rankings was 6.4 which was only Level 1.

The results of the data analysis for the second lesson were similar to the results of the first lesson in that Mrs. L used a total of five tasks, and all five tasks had overall rankings of Levels 1 or 2. Mrs. L also used two tasks that were taken from a source other than the textbook, but neither of those tasks were ranked over Level 2. There was no new material covered during this lesson, so the pattern of instruction differed from the first observation's pattern. The first two tasks were the same as the first lesson's tasks, a speed drill to review basic facts, followed by a homework check, but after the homework check, Mrs. L assigned the midchapter review to assess the students' progress and assign grades.

Mrs. L gave the students twenty minutes to work on the midchapter review, and then she had students share their *Ted and Ed* Stories, by reading them aloud. As mentioned previously, there was no mathematical objective or challenge for this part of the lesson. The homework assignment was only given to the students who did not finish the chapter review in class. Therefore, the brighter or quicker students were rewarded for completing their work by not having homework. The slower or less capable students received homework for not working fast enough in class. This mathematical learning environment was not the type of learning environment described as supportive of reform.

Mrs. L only used two methods of instruction during this lesson: three independent tasks and two whole-group tasks. All but one of the tasks used during this lesson was an exercise. The sharing of the stories was classified as a project because it was a long term assignment that the students worked on both in and outside of class. This sharing session was the conclusion of the project. It did provide time for students to have a voice, but Mrs. L was in control of what was said. Four of the five tasks had overall rankings of Level 1 and the other task was ranked Level 2. Thus, Mrs. L's global rating for the second observation was consistent with the first observation, Level 1.

The third lesson observed during the initial observation had a total of five tasks, and all, except one, had an overall task ranking of Level 1. The other task had a task ranking and an overall ranking of Level 3. The discourse was coded as a two because the students were working in small groups to write five inverse operation-type word problems about their science lab results; however, the main purpose of the group was to share data. During this task the students were permitted to discuss what they were doing, but each person was responsible for writing their own problems. The environment was more student friendly during this activity. In addition, the outcome of the tasks was totally dependent on the students. Mrs. L offered some individual assistance, and she gave a couple of example problems, but the students were expected to write their own problems based upon their groups data. Mrs. L offered an incentive, "I am planning to go through them and make a quiz for you all based on yours, some of the better ones, I hope" (Initial Observation 3, p. 3). Again, anyone who did not complete this assignment in the twenty minutes during class was to finish it for homework. The environment was coded a three for this task, and assessment/evaluation was coded a two; thus, this task had an overall-task ranking of Level 2.

Like the first observation, Mrs. L used a combination of methods of instruction: two independent tasks, one small-group task and two whole-group tasks, and she used two types of instructional tasks. Three of the five tasks were exercises and the other two tasks were applications. Again, Mrs. L did not introduce any new material during this class period so the pattern of instruction was slightly different than the first lesson, but the first two tasks were the same for all three observations: a speed drill that was followed by checking homework. During this lesson the homework check was followed by a small-group application task. This task was to be finished for homework, and then there was individualized-computer-assisted instruction. Even though one of Mrs. L's instructional tasks was ranked as supportive of reform, since the other four were ranked Level 1. Her global rating for the third observation was consistent with her global rankings for the first two observations, Level 1. The analysis results' for Mrs. L's first three observations are presented in Appendix S (see Tables S1, S2 and S3).

Mrs. L's methods of instruction and her types of tasks were consistent during all three lessons observed. The only exception was a small-group task in the third observation. The majority of the fifteen tasks observed during the initial observation had overall rankings of Level 1. Four tasks had overall rankings of Level 2 and one had an overall ranking of Level 3. Although Mrs. L did use small-group tasks in two of the three lessons observed, the overwhelming majority of the observed tasks, thirteen, were independent or whole-group type tasks. These tasks usually followed the pattern of check work, whole-group guided practice and independent practice. Eight of the fifteen tasks were from sources other than the textbook, but only two of those tasks were coded as supportive of reform. In addition, only one had an overall-task ranking that was supportive of reform. Two-thirds of the tasks were exercises, and the other third were split between applications, projects, and questions. Mrs. L was a strong believer in the adage "practice makes perfect." She planned mathematics instruction to provide the students with the exact information they needed to know. She also gave plenty of practice tasks for mastery of the skill or information that was taught. Mrs. L's global ranking for the initial observation was Level 1.

Analysis Results of Mrs. L's Follow-up Observations

The first lesson observed for Mrs. L's follow-up observation began with the same two tasks that were used in all three of the initial observations. Class was started with a speed drill, followed by checking homework answers. Of the seven tasks observed, six had overall-tasks rankings of Level 1. As in the third lesson observed in the pervious set of data, the other task had an overall-task ranking of Level 3. This task diverged from the objective of the day, computation with integers, and involved the students in working with their table partners on a problem-solving task about patterns. Mrs. L encouraged the students to work by offering the first group who answered the problem correctly, the option of not doing the next assignment. Before the students started to work, Mrs. L explained the directions, discussed the meaning of a pattern, and told them what to do first. As the students worked on this task, finding the total number of paths through a triangle, Mrs. L walked around the room asking students to explain the directions to her. She told them to think logically, verify their paths, and check their answers. After approximately fifteen minutes of work time, one group had solved the problem. Mrs. L had them explain their pattern to the rest of the class.

The task discourse, as well as the task itself were both coded a three, and the environment and assessment were both coded a two; thus, the overall-task ranking was Level 3.

Mrs. L used a variety of methods of instruction, but half of the tasks were whole-group direct instruction tasks. The methods of instruction observed varied also. There were two independent tasks, one small-group task, and four whole-group tasks. As in the initial observation, whole-group tasks were used most often. Five of the seven tasks were taken straight from the textbook, and the types of tasks observed during this lesson were one problem solving, five exercises, and one question. As in the initial observation, exercises were the type of tasks used most often for mathematics instruction. Mrs. L's global ranking for this lesson was consistent with the her global ranking for the initial observation, Level 1.

Although Mrs. L did vary her instructional routine slightly by inserting the small-group problem-solving task after checking homework, the rest of her instruction followed the same pattern as the initial observation. After the solution to the problem-solving task was given, Mrs. L assigned a quick assessment task on the multiplication of integers. The next three tasks in order were (1) whole-group direct instruction about division of integers, (2) whole-group guided practice and (3) independent practice. Other than the problem-solving task that did not relate to the lesson, Mrs. L's rigid plan of instruction was in observed throughout this lesson.

The analysis results of the second follow-up observation were similar to the first follow-up observation's results. As in the first lesson observed, the second lesson consisted of seven tasks. Five of those tasks had overall-task rankings of Level 1, one was ranked Level 2, and one was ranked Level 3. In this lesson, Mrs. L changed her opening class task from a speed drill to reviewing the four assessment problems from the previous day's lesson; however, she used the same second task of checking homework. After checking homework, Mrs. L assigned a quick two question informal assessment task. This was followed by a small-group practice. As in the previous lesson, the small group practice was followed by whole-group direct instruction to introduce new material, and whole-group guided practice. Independent practice was a small-group task rather than an individual task. This instructional pattern was consistent throughout all the lessons in which new material was introduced.

As in the previous lesson, whole-group instructional tasks were used most often as the method of instruction. Similarly, Mrs. L again used a combination of whole-group, independent, and small-group tasks. Four of the observed tasks were whole group. There was one each of the following types of tasks: small group, partner, and individual. Another common characteristic between the follow-up observations was that the majority of the instructional tasks were taken from the textbook materials. The types of instructional tasks for this lesson were consistent with the mixture used in the previous lesson. Like the previous lesson, exercise tasks were used most often for mathematics instruction. During this class, the following types of instructional tasks were observed: three exercises, two applications, and one question. The majority of the tasks observed during this lesson were Level 1, thus, Mrs. L's global ranking for the second follow-up observation was Level 1. A summary chart of the data for the follow-up observations is presented in Appendix S (see Tables S4, and S5).

<u>Comparison of Mr. L's Data.</u>

At first glance, there are some outstanding, common characteristics of the two sets of data, the initial and follow-up observations. Sixty-five percent of the tasks were exercises, and about half of the instructional tasks were whole group. At least sixty-six percent of the tasks had Level 1 overall-task rankings (see Table 11). Mrs. L used a variety of methods of instruction and types of instructional tasks in both sets of data, but another characteristic common to both sets of data was that at least one task in each observation was supportive of reform. Mrs. L planned small-group tasks as both another form of practice for the students and assist in matching the students' interests during the hour and twenty-five minute long class. During these lessons, Mrs. L talked with the students instead of at them; therefore, the atmosphere in the room changed ever so slightly. Students voices were heard talking to one another. Although the acoustics in this room were horrible, the sounds of muffled voices were heard underneath the sound of Mrs. L's voice echoing off the walls as it did whenever she addressed the whole group.

The results of both sets of data supported that Mrs. L believed that being a successful mathematics students required the memorization and quick recall of basic facts. In addition, drill-and-rote practice was essential for students to increase their speed and accuracy of basic facts. This same belief about learning was seen in all of Mrs. L's mathematics instruction. As mentioned earlier, when Mrs. L introduced new material she used the following combination of tasks: direct instruction, guided practice, and independent practice. This was seen in both sets of data. Mrs. L believed it was her responsibility to provide the students with enough practice to master the mathematics objective being taught. In three of the five lessons, one of those tasks was a task that actively involved the students in problem solving. Mrs. L selected these tasks with deliberate attention to connecting mathematics to the real world and to other subjects. This was the part of the reform suggestions that she adopted and put into use.

During every lesson observed, Mrs. L had the students check the answers to their homework or class work from the previous day. Either she or a drafted student would state the correct answer. During each lesson observed, the students turned in at least one written assignment for a grade. Mrs. L used these assessments to determine students' grades as well as to determine which students needed extra help. Students were usually expected to correct their mistakes and then return their papers to earn a better grade. There was no evidence that this information influenced Mrs. L's instructional planning. The students were expected to master the objective being taught in the one or two lessons devoted to that objective. After the second day, if they still didn't understand, they were expected to arrange to stay after school for individual instruction.

Table 11

A Comparison of Mrs. L's Initial and follow-up Observation Data

Types of Instructional Tasks	**Percent in Initial Observation**	**Percent in Follow-up Observation**
Application	20	14
Construction	0	0
Exercise	66	65
Problem Solving	0	7
Project	7	0
Question	7	14
Methods of Instructional Tasks		
Individual	40	21
Partners	0	8
Small Group	13	14
Whole Group	47	57
Sources of Instructional Tasks		
Textbook	47	64
Nontextbook	53	36
Overall Rankings of Instructional Tasks		
Level 1	66	78
Level 2	27	7
Level 3	7	14
Level 4	0	0

All of Mrs. L's lessons had a procedural focus and memorizing facts for speed and accuracy were constantly stressed as important. No attempts were made to provide the students with concrete experiences to build conceptual knowledge. For the most part, conceptual understanding was ignored. At least ninety percent of Mrs. L's instruction was oral. Occasionally, she would work an example on the board, but illustrations or demonstrations were never used. During both sets of observations, Mrs. L and/or the book were the mathematics authorities in the classroom. When giving directions or going over answers, she referred to— "what <u>they</u> wanted you to do," or "what <u>they</u> said the answer was." Only during three tasks of twenty-nine tasks observed did Mrs. L encourage the students to reason about what they were doing. Even during those tasks she directed their thinking to the best strategy to use. Mrs. L treated her students as passive-dependent learners, and she controlled much of the communication in the classroom. Since the correct answer was always the focal point, discussions about their thinking or reasoning were generally not encouraged even when the students worked in small groups. When the results of the two sets of observations were combined, Mrs. L's global ranking was Level 1. This was reflective of the majority of her instructional practice.

<u>Analysis Results of Mrs. W's Initial Observations</u>

During the first lesson observed, Mrs. W opened class with a whole-group direct instruction task to introduce the mathematics objective of the day (estimating decimal problems' products and quotients). She used the textbook scripted lesson and practice problems from the retired *Addison-Wesley's* sixth grade mathematics textbook (replaced by the *Glencoe* mathematics series adopted in 1993) After Mrs. W worked the example problems about the celebration of America's bicentennial on the overhead projector, she conducted a whole-group, guided-practice task. That is, Mrs. W worked the problem on the overhead while she asked the students leading questions about the arithmetic steps. She usually drafted students to answer these questions. If they did not know the answer, they were encouraged to pay attention as the next student answered the problem. The students were expected to copy the problems as they were worked on the overhead projector. Then they were to use them as examples to do the independent practice assignment that was in the textbook.

During this task, there were three student questions that could have been used to initiate good mathematical discussion regarding the objective being taught. Mrs. W stuck rigidly to the scripted lesson in the textbook, and she did not pursue an investigation to answer the students' questions. The three questions were, "Why wouldn't you round seven [7.3] up to ten?" "Why do you round up to ten when you have a five [8.5]?" "Why did they decide that?" Mrs. W's response to the first question was, "Well, that's not what I'm doing." Her reply to the second question was, "Oh, you want to know why, since its right in the middle, you round it up to nine? Ask Mrs. [researcher].” Mrs. W then quickly moved to the next computation problem. Mrs. W spent at least five minutes explaining and demonstrating a short cut when the factors were multiples of ten. She encouraged them to practice using this short cut. Later in this lesson, Mrs. W asked, “Can you round off and estimate a single digit number?” The student reply was, “Nope.” This type of discourse was not supportive of reform mathematics, and also indicated the students and the teacher believed that mathematics was a set of rules handed down from the mathematicians. In addition, it indicated that in order for the students to be successful, they must pay close attention and do lots of practice.

All four of the tasks observed during this first lesson were textbook exercises with overall task rankings of Level 1. The methods of instruction used were split equally between whole group and individual. Mrs. W’s instructional style most closely matched mastery learning methods of instruction. As mentioned in the typical mathematics lesson description for Mrs. W, she had two mathematics groups in place. One group worked with her through this lesson just described while the other group worked through the book independently at their own pace. This was not a learning environment recommended for mathematics classroom reform. The students who were not in the self-paced or advanced group identified themselves as not being smart. They knew that Mrs. W had lower expectations for them. Many of the students worked hard to practice and learn the procedures Mrs. W taught them, but none of them participated in mathematical reasoning or the communication associated with problem solving and learning mathematics. Mrs. W’s global ranking for this first lesson was Level 1.

The results of Mrs. W’s second observation were consistent with the results of the first. During the second lesson, Mrs. W used the following three tasks: whole-group homework checking exercise, an independent practice exercise, and a homework exercise for anyone that did not finish their work in class. As pointed out before, this is not an equitable practice for the students. The pattern of instruction was the same as the first lesson with the exception that the first task’s whole-group direct instruction was not used to introduce new material, instead was used to review the concepts introduced the previous day. The students had not demonstrated mastery of the skill at this point; therefore, no new material was introduced during this lesson. Like the first task, all three tasks had overall rankings of Level 1. They were all textbook exercises. The methods of instruction used were consistent with the observation of the first one as well. Two individual tasks and one whole-group task were used.

As in the first observation, teacher talk dominated the discourse as Mrs. W used guiding questions to lead the students through the steps for estimating products and quotients with decimals. As the students worked on their independent assignment Mrs. W walked around the room and monitored their work. She checked to make sure that they were following the directions and that their work was neat. She did not encourage the students to communicate with one another, but, rather, to raise their hands and address their questions to her. During independent-practice time, there were always students' hands up in the air seeking assistance. Mrs. W helped the individuals by repeating the procedure and showing them how it should look on their paper. Mrs. W's global ranking for the second initial observation was consistent with the first, Level 1.

The results of the third observation were similar to the results described for both the first and second observations. During this lesson, Mrs. W used four tasks, and all of them were textbook exercises that had overall tasks rankings of Level 1. As in the previous lessons, the methods of instruction were split between whole-group and individual tasks with two of each. The pattern of instruction was consistent with the first lesson observed. After a textbook scripted lesson was used to introduce new material, and the students copied the example problems during guided practice. Then, independent practice was assigned and any problems not finished in class were assigned for homework. Mrs. W's global ranking for this third observation was Level 1. Summary tables of Mrs. W's initial observation are presented in Appendix T (see Tables T1, T2, and T3).

When the data analysis for the three initial observations were compiled the results proved to be consistent in all of the categories. One hundred percent of the tasks were textbook exercises with overall task rankings of Level 1. During all three observations, Mrs. L used a combination of whole-group and individual methods of instruction. The ratio of individual to whole-group tasks was five to six. Mrs. L consistently used traditional methods of instructions in all the lessons observed. She told the students what they needed to learn, showed them how to do the procedures, supplied them with practice exercises to help them memorize the information, assessed their progress, offered individual assistance, and then moved to the next objective. The retired *Addison-Wesley* textbook was the source for all eleven tasks observed. Only the four special students were working on Geometry from the *Glencoe* textbook.. The only characteristic that really varied for these lessons was the amount of time spent working on mathematics, and this ranged from thirty to forty-five minutes per lesson.

Analysis Results of Mrs. W's Follow-up Observations

The results of the first follow-up observation's data analysis were not like the initial observation's results. There were only two tasks, and they had overall-task rankings of Level 2 and 3. One of the tasks was a construction, but they both came from the *Glencoe*

Course 1 sixth grade textbook. Although the objective to identify three dimensional figures and their parts was simple, the method of instruction was a hands-on small-group investigation. The students used gum drops and straws to construct a regular prism. Then they used that figure to answer the lab questions provided by the textbook. The students worked together and discussed their findings by stating what they thought the answers were. Mrs. W concluded the lesson by pulling the whole group back together. She then had them show and tell how they arrived at their answers. The lesson only lasted twenty-five minutes, but during that time the students were engaged in the mathematics task assigned, and they talked about it to one another.

One of the characteristics that this lesson had in common with the initial observation was that all tasks came from textbook sources. The significant difference was that during this lesson, Mrs. W used the county adopted *Glencoe Course 1* textbook instead of the retired *Addison-Wesley* textbook. Mrs. W said that she used the *Addison-Wesley* textbook because it was easier and best fitted the needs of her students, but while teaching Geometry Mrs. W had implemented some of the new textbook's lesson plans. As a result, some aspects of her instruction changed drastically during this lesson. Mrs. W's global ranking for this lesson was Level 3.

Despite the higher overall-task ranking, there were some common characteristics between this lesson and the initial observation. One of those was the types of questions that Mrs. W asked the students. Other than a few questions from the textbook, all of Mrs. W's questions during the discussion were low-level recall questions. There were no connections made during this lesson, and Mrs. W ensure the all the students had a copy of the correct answers before completing the task. The learning environment was still teacher centered. Mrs. W and/or the textbook were the mathematics authorities. Although this lesson helped the students to develop a conceptual understanding of the terms vertex, edge, face, etc., the objective of Mrs. W's lesson was to have students memorize the definition of the words and the names of selected prisms and pyramids.

The data analysis results for the second follow-up observation matched the initial observation. This lesson consisted of three tasks that followed this pattern: whole-group direct instruction review, whole-group guided practice, in which the students copied the example problems as they were worked, and an independent-practice exercise. All of these tasks were from the *Glencoe* textbook and all had overall-task rankings of Level 1. Mrs. L reviewed the steps for finding the area of different polygons in preparation for finding the surface area of three dimensional figures. Then she guided the students through the practice problems in the book. Although there were some higher-level questions in the textbook assignment (i.e., compare prisms and pyramids), the focus of the lesson was for the students to get the correct answers copied. Mrs. W's method of direct instruction did not encourage the students to participate in reasoning, nor problem solving because most students were busy trying to keep up with copying the answers as she wrote them on the overhead. Like the initial lesson, Mrs. W used a combination of whole-group and individual tasks. She did most of the talking, In addition, students were encouraged to direct their questions to the teacher. Mrs. W's global ranking for this lesson was Level 1. A summary of the follow-up observation data analysis is provided in Appendix T (see Tables T4, and T5).

Although there was some variance in the observed lessons during the follow-up observation, the majority of the observed instruction matched instructional practice characteristic of Level 1. Four out of five tasks were textbook exercise, and the majority of these tasks were whole-group or independent type tasks. Three of the tasks were whole group, one was small group and one was individual. The use of small-group tasks was not typical of Mrs. W's mathematics instruction. When Mrs. W was asked about her choices of instruction methods she said that she used whole-group instruction because it was easier for her, and she went on to say the following:

> I just think that when the whole group, the larger group, I can manage focusing on one thing. It is easier for them to concentrate than if you have little groups all over the classroom. Although I know that is the way things are supposed to be, I just don't see how people can concentrate when people are talking and working together. If, sometimes on occasion they can work together, after I have taught what I want to teach, and then they can help each other, sometimes. (p. 6)

The small-group construction tasks used during the first follow-up observation was one of those occasions. Mrs. W used the county's old textbook more than she used the newly adopted textbook. For this lesson, she opted to use the lab activity provided in the new textbook. This was designed to be a hands-on learning activity. During he next day's lesson, Mrs. W used the three dimensional models from the previous day's lesson as visual aids for her whole-group direct instruction. She was once again using the same instructional routine of whole-group instruction, followed by guided practice, followed by independent practice. Thus, the global ranking of Level 1 for the follow-up observation was reflective of the majority of the mathematics instruction observed.

A Comparisons of Mrs. W's Data

As mentioned before, Mrs. W had global rankings of Level 1 for both the initial and follow-up observations.. In both sets of data, the majority of the tasks used for instruction were exercises. One hundred percent of Mrs. W's tasks were from mathematics textbooks. In both sets of data, over fifty percent of the tasks were whole-group instruction. Over half of the tasks in each set of data had overall-task rankings of Level 1 (see Table 12). Mrs. W used the same type of teacher-directed discourse in all the lessons observed, and she consistently expected the students to learn mathematics by listening, watching, copying examples, and practicing. Her method of instruction did not encourage students to reason or communicate about mathematics. All of the lessons focused on procedures, and Mrs. W consistently emphasized that lots of practice to memorize the procedures and/or vocabulary was essential to being successful in a mathematics class.

There was at least one student question in each lesson that could have sparked a mathematical discussion or investigation, but Mrs. W always steered the lesson back to the textbook material. She did not encourage divergent thinking. She showed students the best strategy to use and expected them to practice until they mastered it. In both sets of data, the questions asked by Mrs. W during instruction were low level recall or arithmetic type questions. She consistently encouraged students to be attentive, copy the information they needed, and direct their questions to her. The classroom was teacher-centered; therefore, the students were passive learners.

During both observations, initial and follow-up, neither the discourse or the learning environment were conducive to risk taking, making conjectures, or problem solving. Mrs. W regularly called on students that she suspected were not being attentive. She just as regularly chastised them for not being a better student. The use of two group, one advanced and the other group who were not as advanced, sent a strong signal as to of who was good and not so good in mathematics. Any questions from the advanced group members took precedence over whatever else might be happening in the classroom. More than once during both observations, Mrs. W stopped in the middle of whole-group instruction to answer an individual question from an advanced group member leaving the entire class to sit and wait. Mrs. W did not really encourage questions during instruction, and if students in the regular group did ask questions, Mrs. W often made them uncomfortable by firing questions back at them and putting them on the spot.

When the students worked on independent practice tasks, Mrs. W consistently monitored the students' work for neatness and following directions. She rarely talked to a student about what they were doing, other than to repeat the explanation given during whole-group instruction. She praised the students who were being successful by saying, "Good work." or "You've got it." She also explained what the students were doing wrong if their work was not satisfactory. As Mrs. W moved through the sixth grade SOLs in the order they were presented in the *Addison-Wesley* textbook, she occasionally supplemented her instruction with tasks from the *Glencoe* Textbook. She consistently taught mathematics as a set of isolated skills and as a set of procedures to memorize.

Mrs. W's instructional practice demonstrated that she used the results of formal and informal assessment tasks to determine when to change objectives, as well as when and whom to reteach. When asked about her lesson plans, Mrs. W made the following statement:

> . . .I am sort of like some other teachers that have been doing it [teaching mathematics] for so long that I don't actually write anything down. I just jot down the page number and what the lesson is about, and I don't make out a formal lesson plan. (p. 2)

Table 12.

A Comparison of Mrs. W's Initial and follow-up Observation Data

Types of Instructional Tasks	**Percent in Initial Observation**	**Percent in Follow-up Observation**
Application	0	0
Construction	0	20
Exercise	100	80
Problem Solving	0	0
Project	0	0
Question	0	0
Methods of Instructional Tasks		
Independent	45	20
Partners	0	0
Small Group	0	20
Whole Group	56	60
Sources of Instructional Tasks		
Textbook	100	100
Nontextbook	0	0
Overall Rankings of Instructional Tasks		
Level 1	100	60
Level 2	0	20
Level 3	0	20
Level 4	0	0

Mrs. W also used assessment to determine the students' grades. When asked about her grading policy, she made the following comments. The first comment was Mrs. W's response to a question about homework, "I take them up [homework papers] and I just put a check mark beside that they handed them in. Things they check you can't really grade" (p. 8). Grades were determined by quiz and test's scores. All other written tasks were done until the answers were correct. This was in preparation for the quizzes and tests. As the written tasks were completed, they were checked off. When asked about how students' grades were determined, Mrs. W made this response:

> Basically, I start, I use the chapter test, if they haven't done some of the assignments, I will take off from the average. I feel if they can pass the test, then the daily work shouldn't count as much, because the tests and being able to master the material in the chapter is what I am after. (p. 9)

These statements were reflective of the instructional practice observed used during both the initial and follow-up observations. Mrs. W's global ranking was Level 1.

Analysis Results of Mr. M's Initial Observations

Analysis of the first initial observation's data revealed a familiar pattern of instruction that started with whole-group directed instruction to introduce new material. This was followed by guided practice, independent practice, and a homework assignment. There were four tasks observed during this lesson. Their overall-tasks rankings were equally split between Levels 1 and 2. Three of the observed tasks were textbook exercises. and The other one, the homework task, was an application that was not from the textbook materials. While teaching this lesson, Mr. M used the following methods of instruction: two partner tasks, one individual task, and one whole-group task. Based on these data Mr. M's global ranking for the first initial observation was Level 1.

The majority of the discourse in this lesson was teacher talk. Mrs. M explained and demonstrated to the students how to use a protractor to measure angles. He switched from lecture to guided questioning as he moved from the introduction of the new material to the next task, guided practice. However, he still controlled all the discussion. All of the questions asked were low-level recall and procedural questions. Often Mr., M answered his own questions. Mrs. M also made it a practice to explain all the directions and instructions to the whole group at least twice before he assigned independent practice. Mr. M tried to prepare the students for success by explaining every possible mistake they could make before getting involved in the task. During the direct instruction, Mr. M explained how angle measurement connected to real life as he talked about building a room like their classroom.

Mr. M was the mathematics authority in the classroom, and he provided the students with all the information that they needed to know. He also provided guided and independent practice. This type of instruction encouraged students to be dependent learners, but the students liked Mr. M and they wanted to please him by demonstrating how quickly they learned what he taught them. During the guided and independent practice, Mr. M had the students work with a partner. He encouraged the partners to help one another, but all of the students' questions were directed to Mr. M. As the students worked on their independent, angle-measurement assignment, Mr. M walked around the room monitoring the students' process by checking to see if their answers were correct. Mr. M also provided individual instruction during this time. During the independent-practice task, there was always at least one student waiting for Mr. M's attention with his or her hand raised. Mr. M's individual instruction usually consisted of a guided question type review of the procedure. For example, Mr. M asked the student what to do first, next, and so on. Many of the students just wanted Mr. M to confirm that they were indeed measuring the angles correctly, and Mr. M obliged them.

The learning environment was comfortable, and Mr. M encouraged the students to help one another. However, he removed all the possible problem-solving situations by telling the students exactly what they needed to do to classify and measure angles. He also explained in advance all the possible mistakes they might make (i.e. not lining the edge of the angle up with the zero degree mark, reading the wrong set of measures, or not putting the center of the protractor on the vertex of the angle, and the procedure for measuring an angle that opened to the left or some other direction...). He or the book were the mathematics authorities in the classroom. He indicated to the students that the only two way of knowing if their answers were correct was to check with him or the book. The students participated in the tasks with Mr. M. They were comfortable talking with one another and with the teacher. The learning environment encouraged passive learning and indicated that Mr. M believed mathematics to be a set of skills that the students needed to memorize. His instructional style was traditional with a sprinkle of small-group tasks for practice.

The homework task assigned to follow up this lesson was not the routine textbook assignment that was expected of traditional instruction. It was a real-life application task that challenged the students to be observant about their world by finding examples of three different angles (ninety, forty-five, and thirty degrees) in their homes or neighborhoods. Mr. M did not have the students measure the angles, or write down anything. He just asked that they be prepared to tell him about what they found. This task required the students to reflect on the angles studied in class, and also required them to make connections between what was learned in class and real-world objects. This homework task was not the independent practice exercise that typically accompanied this type of instruction.

During the second initial observation, Mr. M opened the lesson with a discussion of what the students found in around their homes that equaled the three angle measures given. During this discuss nine different students volunteered examples of a ninety degree angle; however, the students only gave three examples of a forty-five degree angle, and two of a thirty degree angle. A student gave the handrail of their stairs as an example of a thirty degree angle, and Mr. M did not question this. After the student's response, Mr. M said that the handrail going up your stairs could be thirty degrees. He continued to the next student who gave an example of a clock. The students were anxious to share their answers, and the class was a respectful audience. After this discussion, Mr. M used whole-group direct instruction to introduce new material. This was followed by guided practice, independent practice and a homework assignment. Other than the discussion to go over homework, this lesson followed the same pattern as the first lesson. As in the previous observation, both the guided and independent tasks were partner tasks.

All of the tasks in the second observation had overall-tasks rankings of Level 2. Four of the five tasks were taken from the *Glencoe Course 1* textbook. Three of the tasks observed in this lesson were exercises. The other two were split between application and question tasks. Consistent with the first observation's data, the methods of instruction used by Mr. M during the second observation included one independent, two whole group and one small group. The discourse used during this lesson was consistent with the type of discourse described in the first observation. Mr. M controlled the discourse in the classroom, and he did most of the talking. He explained and demonstrated to the students how to do clock-angle measurements. He then assigned practice problems. He encouraged partners to help one another, and he also used the same type of individual instruction during the independent practice as described in the first observation's data. Although the homework task for this lesson was a textbook task, it would have been a challenging, problem-solving angle-application task, if Mr. M had not told them the best strategies to use to solve the problems. Mr. M's global ranking for the second lesson was Level 2.

Results of Mr. M's third initial observations data were consistent with the results described in the previous two lessons. During this lesson, he used a whole-group task to check homework. Then he used whole-group direct instruction to introduce new material. This was another real-life problem-solving application of angle measurement (i.e., plotting flight plans). Whole-group instruction was followed by guided practice, then independent practice. During the guided-practice task, Mr. M gave the students the option of working with their partners or individually. The independent task was to be completed individually for a grade. As in the previous lesson, Mr. M demonstrated and told the students every bit of information that they might possibly need to solve the problems before assigning the task. This left the students with a procedural practice instead of a problem-solving task. All four of the tasks were textbook exercises. The following overall-task rankings were assigned: one Level at 1, and three at Level 2. Based on these data Mrs. M's global ranking was determined as Level 2. A summary of the Mr. M's initial observations' data analysis results is provided in Appendix U (see Tables U1, U2 and U3).

Although Mr. M's instructional pattern was based on traditional methods of instruction, he had incorporated some reform practice into the majority of his instruction. During each lesson observed, Mr. M used at least one partner tasks. This opened up lines of communication between the students, and between the students and the teacher. During each lesson observed, he made a deliberate effort to connect the mathematics being taught in the classroom to real life. Sometimes, he did this by telling the students about the connections, and sometimes he selected related tasks that were applications or problem-solving tasks based upon real-life experiences or objects. However, Mr. M consistently removed all problem-solving challenges from the tasks by using whole-group direct instruction. The students were passive learners, and Mr. M and/or the book were the mathematics authority. Occasionally Mr. M asked for an explanation of a problem's solution, but he always took responsibility for explaining the reasons or providing the justification for the answer. To learn mathematics the students were expected to practice the procedures and memorize the vocabulary. Thus, Mr. M's global ranking for the initial observation was Level 2.

Analysis of Mr. M's Follow-up Observation

During the first follow-up observation Mr. M started class off with a whole-group direct instruction review, but this time his direct instruction consisted of a demonstration and guided questions rather than a lecture. This was followed by another whole-group review task of checking the answers to the previous day's class work. Mr. M assigned an assessment task (ten problems selected from the textbook). This assignment had started the previous day. Mr. M reminded the students that they needed to show their work for finding the surface area on their paper. He also told them that each problem was worth ten points. Showing their work meant working out all of the arithmetic procedures for each problem. As the students worked on their independent assignment, Mr. M walked around the room answering students' questions about finding surface area. During his demonstration, Mr. M showed the students that all they really needed to remember was to multiply each number by the other ones twice. Many of the questions were regarding which numbers to pair together to get the surface area.

As the students finished this task, they turned it in, and then they took a break. Some of them waited for as much as twenty minutes for everyone to finish. After all the students turned in their ten problems, Mr. M used whole-group direct instruction to introduce finding the volume of a prism. Mr. M started this task by having a student read the example problem in the book. Then he added his own examples and explanations. The following is an excerpt from this lesson when Mr. M explained how to find the volume of a prism:

> This room would be considered a three-dimensional figure, and we occupy the space on the inside. The walls would be your front, back, top, bottom, and your sides OK? There's space on the inside, and we're in it. So that's the volume. To find the volume of the room all we have to know then is? [waits two seconds] Multiply the length of the room, the width of the room and the height of the room. OK? and that will tell us how much space we got [sic] on the inside. Now look on the opposite page in the red box. It gives in words, and also in symbols the volume, V, of a rectangular prism equals the product; product's the answer of what kind of problem?
>
> Multiple responses: Multiplication.
>
> M: Multiplication problem of its length, l, width. w, and height, h. In symbols, V is equal to l w h. So instead of multiplying by two numbers this time you are multiplying by what?
>
> Multiple responses: Three.

This excerpt is an example of the same type of instructional discourse that was described in the initial observation's data results. Although the sequence of events in this lesson varied slightly, the pattern of the lesson was exemplary of traditional methods of instruction. During the guided and independent-practice tasks, Mr. M determined who needed additional assistance on finding surface area. He provided individual instruction before he moved to the new task of finding volume. Like the lessons in the initial observation, the focus of this lesson was procedural. When new material was presented, Mr. M's goal was to tell the students all the necessary facts, procedures, and information. This excerpt also showed Mr. M's tendency to say everything at least twice to the students. It provided examples of the low-level type questions that he used during mathematics instruction. The questions that the students asked about which numbers to pair indicated that the students did not have a conceptual understanding of finding surface area. It also indicated that a concrete readiness task was needed by many of these students, but Mr. M's instructional decisions were limited to the following: who to reteach and work with individually and when to change tasks.

There were four tasks observed during this first follow-up observation, and two of them had overall task rankings of Level 1. The other two were ranked Level 2. The methods of instruction that were observed were three whole-group tasks, and one individual task. Three of the four tasks were from textbook materials, two of the tasks were questions, and two were exercises. During this lesson, Mr. M used an independent assessment task in place of the small-group task, but otherwise the data for this observation was consistent with the data for the initial observation. Mr. M's global ranking for the first follow-up observation was Level 2.

The second follow-up observation started, like the other lessons observed, with a whole-group review. Mr. M returned the graded ten surface-area problems to the students, and instructed them to make corrections. After providing the students with an opportunity to ask questions, he next reviewed using guided practice problems to find the volume of prisms and cylinders. Again the focus of the lesson was on procedures. During this task, Mr. M introduced the formulas for finding the volume of cylinders or prisms as V=Bh. Then he asked the students questions about finding the area of a rectangle and a circle. After the whole-group guided practice, Mr. M assigned an independent-practice exercise on finding volume. During this independent practice, Mr. M permitted the students to use a calculator. He encouraged the students to direct all questions to him and to look at their examples.

Mr. M's pattern of instruction was characteristic of traditional methods of instruction, beginning with the opening task of correcting their assessment papers from the previous lesson to the guided practice prior to the last independent practice task. As in the previous lesson the discourse used did not encourage problem solving or reasoning. It was teacher dominated. The three tasks used during this lesson had overall-task rankings of Level 1. The methods of instruction observed were similar to the methods observed in the previous lesson with one independent and two whole-group tasks. All three tasks were from the *Glencoe* textbook. The types of instruction used were two exercise tasks and one question. Based on these data, Mr. M's global ranking for the second follow-up observation was determined as Level 1.

There were a total of seven tasks observed during the follow-up observation. Of those, five had overall-task rankings of Level 1. The other two tasks were ranked Level 2. There were two independent tasks, and five whole-group tasks observed. Six of the seven tasks were from the *Glencoe Course 1* textbook. Four out of seven tasks were exercises and the other three were questions. The discourse and learning environment observed during the follow-up observation did not encourage students to be active independent learners; thus, the global ranking of Level 1 for the follow-up observation was reflective of the majority of the instructional practice observed. A summary of Mr. M's follow-up observation's data analysis is provided in Appendix U (see Tables U4, and U5).

A Comparisons of Mr. M's Data

Although the data from the initial and follow-up observations had different global rankings, Level 1 and 2 The two sets of data had many similar instructional characteristics. In both sets of data, over fifty percent of the instructional tasks were exercises, eighty-five percent of the tasks were from the sixth-grade *Glencoe Course 1* textbook, and one hundred percent of the tasks had overall-tasks rankings that were either Level 1 or Level 2 (see Table 13). During the initial observation, about one-third of the tasks were partner tasks. in the follow-up observations were partner tasks. In the follow-up observations, the partner tasks were replaced with independent assessment tasks; thus, communication between students was not encouraged and the overall-task rankings were lower. In both sets of observations, Mr. M used instructional strategies associated with traditional methods of mathematics instruction. In the initial observation, there were several indicators of reform instruction present that were not present in the follow-up observations' lessons.

However, descriptions of the discourse and learning environment observed for both sets of data indicated that Mr. M's method of instruction was consistent throughout both observations. During both the initial and follow-up observations, Mr. M's mathematics instruction encouraged passive dependent type learning. Students practiced the examples provided by the teacher, memorized the procedures and/or vocabulary, and demonstrated mastery by making a passing grade on a written assessment.

When the data for the follow-up and initial observations were combined the question was— Should Mr. M's global ranking be a Level 1 or 2? Out of twenty tasks observed during the follow-up lesson, eight of them had overall-task rankings of Level 1 and twelve had overall task rankings of Level 2. As described in the summary of the initial observations, Mr. M had incorporated some reform aspects into his instruction and the majority of his instructional tasks were representative of this type of instruction.

In Mr. M's class, mathematics was a set of facts and information that needed to be practiced and memorized in a sequential order. Mr. M's lessons were connected to one another in that the teach-assess-teach routine flowed from one lesson in the book to the next. In every lesson observed Mr. M's goals were to provide the students with all the necessary procedural knowledge, show the students how to correctly manipulate the mathematical symbols, and assess their progress by looking or listening for correct answers. The average of all twenty global tasks rankings placed Mr. M's global ranking at the top end of Level 1.

Table 13.

A Comparison of Mr. M's Initial and Follow-up Observation Data

Types of Instructional Tasks	**Percent in Initial Observation**	**Percent in Follow-up Observation**
Application	15	0
Construction	0	0
Exercise	77	57
Problem Solving	0	0
Project	0	0
Question	8	43
Methods of Instructional Tasks		
Independent	31	29
Partners	31	0
Small Group	0	0
Whole Group	38	71
Sources of Instructional Tasks		
Textbook	85	85
Nontextbook	15	15
Overall Rankings of Instructional Tasks		
Level 1	23	71
Level 2	77	29
Level 3	0	0
Level 4	0	0

Combined Data Analysis Results for Both Sets of Observations

Out of 139 tasks, 14 had overall-tasks rankings of Level 4. Thirty-nine tasks had overall-tasks rankings of Level 3. Thirty-four tasks had overall-task rankings of Level 2, and 52 tasks had overall-task rankings of Level 1. According to the six participants' global rankings, three of the participants used instructional practice that was weakly or nonsupportive of reform, one used instructional practice that was marginally supportive of reform, and two used instructional practice that was supportive of reform. However, the results of the overall-tasks rankings indicated that five of the six participants used instructional practice that was supportive of reform at least one time during the five observations. The combined data analysis results for each participant are presented in Table 14.

Table 14.
Total Task Rankings for Initial and Follow-up Observations for Each Participant.

	Level 1	Level 2	Level 3	Level 4
Mrs. D	5	12	4	3
Mr. A	2	3	10	6
Mrs. W.	14	1	1	0
Mr. M	8	12	0	0
Mrs. L	21	5	3	0
Mrs. N	2	1	21	5

Conclusion

The first section of this chapter described how the classroom doors of Pleasant Middle School were opened to provide a snapshot view of the mathematics instruction going on inside. After the participants' typical mathematics lessons were presented selected classroom doors were opened to give examples of instructional practice that was representative of the four global levels of instruction used during Level I data analysis. The next section presented the results of each participant's initial and follow-up observations' analysis results. Summaries of the data analysis results of the participants' initial and follow-up observations were followed by comparisons of the two sets of data. This was done to determine if the instructional practice observed during the initial observation was consistent with the instructional practice observed during the follow-up observation, as well as to verify the global rankings assigned. The analysis results of Level I are used in Level II of the study to provide a summary of the combined results of both sets of observational data for all the participants that focuses on the identification of instructional practices that match the recommended reforms.