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A STUDY TO DEVELOP AND IMPLEMENT DIFFERENTIATED, HANDS ON MATHEMATICS INSTRUCTION STRATEGIES TO IMPROVE STUDENT LEARNING

By
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A Thesis

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Professor

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ABSTRACT

Edmund F. Cetrullo Jr.
A STUDY TO DEVELOP AND IMPLEMENT DIFFERENTIATED, HANDS ON MATHEMATICS INSTRUCTION STRATEGIES TO IMPROVE STUDENT LEARNING
2004
Dr. Ted Johnson
Master of Arts in School Administration

The purposes of the study were to research, develop and implement differentiated, hands on mathematics instruction strategies with mathematics teachers in grades six through eight for improvement of student learning. Teachers, through collaborative action research, created and implemented student centered, discovery based, hands on, manipulative centered lessons over two marking periods which provided students with experiential, problem solving, mathematical situations that met their individual and group needs. Analysis of this case study yielded growth through a triangulation of data measured from improved student scores, student observations, and teacher reflection about their pedagogy. Effective classroom strategies for differentiated, hands on instruction are discussed.

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Chapter 1

Introduction

Focus of the Study

The study focused on the enhancement of mathematics instructional strategies for teachers in grades six through eight. During the previous school year, informal observation of mathematics teachers and students at the G.S. School has allowed for the recognition of antiquated, rote, mathematics instruction strategies. The instruction focused on training students in computation, and not allowing students the opportunity to apply mathematical concepts towards experiential, problem solving situations individually and in cooperative groups. The lack of these opportunities had fostered an inability for students to make a mathematical connection to problem solving situations of the real world.

Although G.S. School students normally perform proficiently on standardized assessments and yearly reports, in the classroom they struggled on how to use mathematics when given an applicable problem solving situation.

Through action research, teachers researched, developed, and implemented lessons to provide students with differentiated, hands on instruction which included experiential, problem solving situations.

Purpose of the Study

The purpose of this study was to develop and implement differentiated, hands on mathematics instruction strategies to improve the students' application of mathematics towards problem solving in experiential, problem solving situations.

Teachers of mathematics in grades six through eight, researched, developed, and implemented experiential lessons to provide their students with differentiated, hands on mathematics instruction. The teachers provided for a variety of mathematical opportunities that actively engaged and challenged the students in more than just mathematics. The majority of the lessons mandated students to work in cooperative groups, creating opportunities for students to interact, plan, and create roles for the successful completion of the activity.

Definitions

Differentiated instruction is the use of non-traditional teaching strategies that promotes the teacher meeting the individual student or group needs through a variety of activities. Differentiated mathematics instruction would provide for students to learn through various activities such as experiential, hands on, manipulative based, problem solving situations implemented through individual and cooperative group activities.

Learning is knowledge acquired through study and that may be applied to a future problem solving situation. Learning is discussed as the comprehension of a mathematical concept and being able use the concept for application and synthesis.

Manipulatives are tools that may be used to problem solve. The use of manipulatives for the implementation of differentiated, hands on mathematics instruction strategies in this study referred to the use of tools of measurement, materials such as plastic cubes, wooden dowels, paper cut-out shapes, rubber bands, boxes, toothpicks, glue, three dimensional geometric shapes, and other common items found in a mathematics classroom.

The triangulation of data is the recognition, acceptance, and validation of a theory based on the commonality of a theme that is present in three different data sources. The triangulation of data in this study resulted in the overall achievement of students that was evident through quantitative and qualitative data such as pre and post student scores, pre and post teacher surveys, and observations from excerpts of teachers' reflective journals.

Quantitative data is data that is objective and measurable by number. The quantitative data measured in this study was twofold. Pre and post mean scores of each grade level which participated were analyzed. Also analyzed were the mean (see Appendix C), range (see Appendix D), and percent of change scores (see Appendices E and F) of pre and post Likert Scale surveys (see Appendix A) which identified mathematics instruction strategies and attitudes of teachers.

Qualitative data is data that is subjective and measurable by condition. The qualitative data analyzed in this study were ascertained through the teachers' reflective journals (see Appendix B) and identified in the pre and post Likert Scale surveys (see Appendix C).

Limitations of the Study

The study was a volunteer driven initiative, enlisting mathematics teachers from grades six through eight. The original design of the study called for greater teacher participation, however volunteers were difficult to find as teachers were working the school year without a settled contract.

Data was collected and analyzed to identify the effective use of differentiated, hands on instruction by teachers. The results of these actions, the improvement of instruction and student progress, was measured through the triangulation of qualitative and quantitative data measured from teacher reflection about their pedagogy, student observation, and students' marking period scores. These results were classroom specific, as they can only be compared to the teachers' previous behaviors and the students' previous performances, thus limiting the research.

Resources available to teachers were also limiting. Textbooks used in each of the grades did not provide for an abundance of problem solving situations. The majority of the experiences were the result of researched activities or teacher creativity. Materials for the activities were also limiting, as many lessons called for non-traditional supplies.

Setting of the Study

The site of the study was limited to grades six through eight at the G.S. School, the only building in the pre-K through 8th grade district. The population observed was a convenience sample which consisted of 23 sixth graders, 28 seventh graders, and 28 eighth graders from eight different classes. The entire school has a student population of approximately 330 students with each grade having homogeneously mixed classes for mathematics.

The participants of the study were volunteer mathematics teachers in grades six through eight at the G.S. School. This convenience sample was limited to five cooperating teachers. Each of these highly qualified teachers had ten to twenty-five years of experience in the instruction of mathematics for middle school aged students in both regular and special education.

The administration of the building is comprised of a superintendent/principal, a special services director, and a part-time business administrator. The district is governed by an elected school board.

The school is set on the Eastern border of C. County, N.J. with a land area of 2.2 square miles. The town's population of 2,435 (year 2000), 49.7% males and 50.3% females, has a racial balance of: White, Non-Hispanic (92.8%), with ancestries of Irish (28.5%), German (22.1%), Italian (19.5%), English (15.9%), Polish (6.4%) and Welsh (2.6); Black (2.8%); Hispanic (2.4%); American Indian (0.7%); and Other (1.7%).

The median resident age is 38.6 years. The median household income is $57,325. The median house value is $117,500.

For the town's population 25 years of age or older, 84.7% graduated high school, 23.3% earned a Bachelor's degree, and 6.6% earned a Graduate degree or a professional degree.

The G.S. School is a suburban, middle class school district that has been sheltered between much larger and diversified communities. Its students are educated in the same building from Pre-K to eighth grade, thus being identifiable by just about every staff member in the building. Students usually find a comfortable niche within the school where they can experience success, whether it is on a sports team or in the school play. Educationally, G.S. School students generally perform well on standardized and classroom assessments. Whenever a student experiences difficulty, it is quickly identified and remedied by a caring and professional teaching staff.

The G.S. School is the focus of the community where many school and community organizations meet to hold their events. The school and community are close knit. Many community members are school employees and many of the students' parents were once G.S. School students as well, thus creating a proud, caring, and effective school and community.

Significance of the Study

The significance of the study was the assessment and enhancement of existing antiquated mathematic instruction strategies for improved student learning. Students of the G.S. School continually performed proficiently on their standardized and classroom assessments, however when a lesson or assignment deviated from the norms created by their teachers and textbooks, students had great difficulty assessing a situation, strategizing a plan, applying mathematical concepts, using manipulatives, and working cooperatively to solve problems. This action research study allowed for teachers to enhance their mathematics instruction strategies, to develop meaningful experiential situations in the classroom, and to implement them through individual or cooperative group activities to improve student learning. These experiences have created memorable discoveries that have not only influenced the past and present, but should influence the future.

Organization of the Study

The study was organized to promote action research about differentiated, hand on mathematical instruction among the mathematics teachers who have volunteered. The volunteers met on a regular basis to research, develop, and implement into their classrooms differentiated, hands on instruction through activities that promoted experiential, problem solving situations that were completed individually and in cooperative learning groups. The effectiveness of the instruction was measured through various data collection procedures that included teacher reflection about their instruction strategies, teacher observation of student progress during activities, and student scores.

Chapter 2

Review of the Literature

Introduction

Student achievement in mathematics has been a part of the national focus for decades and many attempts have been made to stimulate curriculum and instruction. Hands on manipulative use to teach abstract and concrete mathematical concepts have been attempted in many forms with mild successes. The use of these mathematical tools has gained research support in the past decades (Raphael & Wahlstrom, 1989), however the correct formula for its implementation is still being discovered.

In 1989 and 1991, the National Council of Teachers of Mathematics (NCTM) released its Curriculum and Evaluation Standards for School Mathematics (Kennedy, 1998). These standards set higher expectations for mathematics instruction and have offered new strategies to meet these higher expectations. The NCTM standards proposed that all students be provided meaningful experiences to explore and reason through non-routine problems (Ernest, 1994). These standards were,

> based on the most current research on educational and work force needs...realistic and applicable to students of all ages, nationwide...endorsed by 15 math associations, societies, conference boards, councils, institutions, etc. and supported by 25 professional organizations...and have potential, if effectively employed, to level the playing field for minorities and women, who perform poorly in traditional mathematics coursework. (Carlson, 1992)

These standards offer guidelines for enhancing mathematical improvement through manipulative programs; however the needed improvement lies within the instruction. Implementing the ideas in the classroom remains the true obstacle because of antiquated curriculum and instructional strategies. Districts must dedicate resources towards aligning curriculum with these standards and provide meaningful professional development opportunities so educators may best meet the needs of their students. If districts are attempting these reforms, the change must occur with the teachers leading the way by first initiating a change in classroom instruction. Unfortunately, this change only occurs with motivated, dedicated teachers and requires patience on the part of administrators, who are usually interested only in measurable outcomes. The effectiveness of the differentiated, hands on instruction will only yield long term measurable outcomes if the strategies are employed continuously, however the measurement process may be non-traditional itself, relying heavily on individual student observation.

Most teaching in schools suffers from two conditions: (1) a lack of time spent on the subject matter, and (2) passive teaching strategies which rely on textbook use (Marlow & Inman, 1997). Designing effective experiences requires teachers with a proficiency in using and helping students use technology and other tools to pursue mathematical investigations along with the ability to guide students in individual, small group, and whole class work (Ernest, 1994). Districts need to gear professional development opportunities for teachers who shy away from exploring these instructional strategies. Once teachers experience the empowerment of non-traditional lesson building and observe the results of their lessons, meaningful change will occur. However, many times teachers are proficient in one method and teach students as a whole class although some students may not learn that well that way (Rust, 1999).

One main issue hindering the implementation of differentiated, hands on mathematics instruction is the lack of quality textbook publications. If the goals of textbooks coincided with the NCTM's standards, teachers would have developed strategies to meet such standards with lessons that,

> are creative; emphasize comprehension and problem solving, not just memorization; train students to use calculators or computers effectively to enhance, not replace, knowledge of basic skill; and use manipulative materials to promote maximum comprehension. (Carlson, 1992)

Even though some mathematical programs supply opportunity or knowledge to help teachers overcome the challenge of adopting the new philosophy of their programs; when it is time to teach, the teacher's main challenge is to create situations whereby the manipulatives are used for uncovering, not just discovering (Waite-Stupiansky & Stupiansky, 1998), thus changing their role from a purveyor of knowledge to one of facilitating action.

The goals of the NCTM, to use hands on activities and manipulatives for meaningful mathematics instruction, will not only teach students what concepts they should learn, but also teach students how to learn. Unfortunately, standards alone will not supply the necessary ingredients to change traditional teachers into math facilitators. One deficit teachers must overcome is how to properly teach hands on activities. It must take initiative, insight, effort and access to a successful program to use as a model. Teachers who are using manipulative math with success are the most reliable resource to help initiate this change.

Marilyn Burns boasts 30 years of manipulative instruction and offers Seven Musts for Using Manipulatives:

1. Discuss the importance of how manipulatives help students learn math.
2. With the help of students, create ground rules for manipulative usage.
3. Store manipulatives in a place that is familiar and accessible to students.
4. Allow time for free exploration of the manipulatives.
5. Create classroom charts about manipulatives enhancing their value.
6. Use the manipulatives for cross-curricular instruction.
7. Invite parents to partake in manipulative activity. (Burns, 1996)

Sandra Waite-Stupiansky, Ph.D. and Nicholas G. Stupiansky, Ph.D., elementary education professors at Edinboro University, feel that a good amount of time must be spent between the facilitator and the students using manipulatives. They state that simple guidelines for planning hands on activities should include: dialoguing, questioning, integrating manipulatives and other tools, writing, and evaluating (Waite-Stupiansky & Stupiansky, 1998).

Jim Koutsos successfully implements a hands on program in Maryland stating that, "This puts traditional concepts in the context that kids can solve" (Koutsos, p. 26). He also emphasizes the importance of longer periods to complete his activities.

Literature and research offer the necessary components needed for meaningful differentiated, hands on mathematics instruction with manipulative use. The NCTM has provided curriculum and evaluation standards for mathematics instructors to attain. Situations of successful differentiated, hands on mathematics instruction are becoming more common. The methods to create these successful situations have come from zealous mathematics teachers who have been properly trained and have a commitment to these revolutionary teaching and classroom management strategies. These strategies of instruction enable students the freedom to explore and discover mathematical concepts while using a variety of processes and manipulatives. How to attain these successful teaching situations will be an individual journey for each educator; however the most recognized common threads include:

1. Create expectations with the students giving them a sense of empowerment and commitment. Invite them to make norms of classroom management and their learning.
2. Allow for flexibility within the lesson. Invite them to explore. Individual students may learn different concepts other than the expected objectives, thus creating a true discovery moment. Patience during a lesson is paramount.
3. Relate classroom work to students' knowledge base. Make the lesson relevant to them.
4. Incorporate various modes of instruction using practices not only common to mathematics instruction. Create opportunities for students to write, speak, and draw about their learning.

Chapter 3

The Design of the Study

Introduction

Mathematics instruction has been primarily computation based, not active problem solving, manipulative oriented, or differentiated to meet the needs of the individual student or group. This case study research focused on the enhancement of instruction through action research, which allowed for the development and implementation of new lessons in the classroom. The results of these actions, the improvement of instruction and student learning, was measured through the triangulation of qualitative and quantitative data measured from teacher reflection about their pedagogy, student observation, and students' marking period scores.

General Description of the Research Design

The analysis of the research was a summative case study format focused on the improvement of mathematics instruction for students in grades six through eight using pre and post study data. The improved instruction was measured by comparing qualitative and quantitative data gathered prior to and following the action research sessions in which teachers developed and implemented differentiated, hands on mathematics instruction. The results of this action produced evidence of growth yielded through a triangulation of data.

Quantitative data was gathered through the comparison of students' mathematics scores for two marking periods prior to and two marking periods during the implementation of the new instructional strategies. The mean score of each student was averaged to create a grade level mean score for both of the two marking period time frames.

Qualitative data was gathered through surveys (see Appendix A) that were issued to participating teachers to ascertain their most commonly used instructional strategies. Teachers' characteristics were identified through a Likert Scale which identified their preferred mathematics instruction strategies and attitudes. Surveys were also administered following the implementation of the differentiated, hands on instruction that measured the change in teachers' mathematics instruction strategies and attitudes.

Other qualitative data was collected through individual teachers' reflective journals (see Appendix B for Reflective Journal Excerpts). These recorded personal and student observations in relation to the differentiated, hands on instruction.

Development and Design of the Research Instrumentation

To bring about innovative instructional change is a long and personal commitment that requires a teachers' awareness about their instruction and a desire to improve. The research instrumentation was developed and designed to create a sense of security and privacy for the participants. The survey (see Appendix A) and reflective journal (see Appendix B) were created to allow for a self evaluation in relation to teaching practice with a focus on differentiated, hands on instruction. The journal provided for an intimate sounding board that posed no ill consequences. Participants were not placed in uncompromising situations as they simply had the option not to offer excerpts of their reflection.

The reflective journal also provided for a forum to record anecdotal student observations directly related to the differentiated, hands on instruction. This proved to be an invaluable data source for student learning.

The mean scores of students were chosen for their quantitative value and provided for a different technique of gathering data used for triangulation.

Description of the Sampling and Sampling Techniques

The participants of the convenience sample study were five volunteer mathematics teachers in grades six through eight at the G.S. School. Each of these teachers had ten to twenty-five years of experience in the instruction of mathematics for middle school aged students in both regular and special education.

The population of the study was limited to grades six through eight at the G.S. School. This convenience sample population consisted of 23 sixth graders, 28 seventh graders, and 28 eighth graders from eight different classes. Each grade level was broken into homogeneous groups related to mathematical ability. This was ascertained by previous tracking in the elementary level. The eighth grade high group studied Algebra I, with a curriculum comparable to a high school level Algebra I class. The lower eighth grade groups studied Pre-Algebra, with a curriculum comparable to most junior high schools or middle schools. The seventh grade high group also studied Pre-Algebra. The lower seventh grade groups and the sixth grade groups followed traditional curricula topics.

Description of the Data Collection Approach

Quantitative data was gathered through the comparison of students' mathematics scores for two marking periods prior to and two marking periods during the implementation of the new instructional strategies. The mean score of each student was averaged to create a grade level mean score for both of the two marking period time frames.

Quantitative and qualitative data was gathered through pre and post surveys (see Appendix A) that were issued to participating teachers to ascertain their most common mathematics instruction strategies and attitudes prior to and following their action research. Teachers' strategies and attitudes were identified through a Likert Scale which identified their preference of instruction. Number scores, 1 through 5, were affixed to responses. A score of a 1 was representative of a strategy or attitude that the participant strongly disagreed with, while a score of a 5 was one they strongly agreed with. A score of a 3 yielded a neutral response. Calculations were made to find the mean (see Appendix C), range (see Appendix D), and percent of change (see Appendices E and F) for each statement the participants responded to in order to identify trends in their behaviors and attitudes.

Other qualitative data was collected through individual teachers' reflective journals (see Appendix B). These recorded personal and student observations in relation to the differentiated, hands on instruction. Information from the journals was totally voluntary and provided another forum to reflect changing attitudes about instruction and observation about student learning.

Description of the Data Analysis Plan

The analysis of the research was a summative, case study format focused on differentiated, hands on mathematics instruction for students in grades six through eight using pre and post data. The differentiated, hands on instruction was measured by comparing qualitative and quantitative data gathered prior to and following the action research in which teachers developed and implemented differentiated, hands on mathematics instruction.

The objective of the study was to improve mathematics learning using three different types of data which were gathered for triangulation. The improvement of student scores in mathematics over two marking periods, positive changes in teachers' mathematics instruction strategies and attitudes about teaching through differentiated, hands on mathematics instruction strategies, and the observations of students during the use of differentiated, hands on mathematics instruction strategies were analyzed. Commonalities in each of these three different data sources were identified for triangulation. Each area of the study supported improved student learning which were evident in the results of the pre and post surveys, calculations of student mean scores at each grade level, and the recorded observations in teachers' reflective journals.

Chapter 4

Presentation of the Research Findings

Introduction

The research study, to develop and implement differentiated, hands on mathematics instruction strategies to improve student learning, yielded modest growth which was evident through the triangulation of data that was gathered through the research instruments. The quantitative post study data boasted overall trends of enhanced mathematics instruction and improved student learning; however it was the qualitative anecdotal data that proved to identify specific learning outcomes and provided positive assurance of student learning.

Grand Tour Question

What will be the effectiveness of the implementation of the differentiated, hands on mathematics instruction strategies on student learning?

One aspect of the quantitative data gathered compared students' mathematics scores for two marking periods prior to and two marking periods during the implementation of the new instructional strategies. The mean score of each student was averaged to create a grade level mean score for both of the two marking period time frames. Overall all grade level mean scores increased during the implementation of the differentiated, hands on mathematics instruction strategies. The sixth grade mean score increased 1.4%, from 89.1% to 90.5%. The seventh grade mean score increased 1.55%, from 88.65% to 90.2%. The eighth grade mean score increased .8%, from 87.7% to 88.5%.

The increased student scores were a result of the implementation of new mathematics instruction strategies. Teachers provided improved, innovative instruction which resulted in improved learning and scores.

The results of the survey measured quantitative and qualitative data. Specific items were created to recognize the participating teachers' most commonly used mathematics instruction strategies and mathematics attitudes prior to and following their action research. Teachers' characteristics were identified through Likert Scale scores. Number scores, 1 through 5, were affixed to responses. A score of a 1 was representative of a strategy or attitude that the participant strongly disagreed with, while a score of a 5 was one they strongly agreed with. A score of a 3 yielded a neutral response. Calculations were made to find the mean, range, and percent of change to analyze the teachers' responses to identify changes in their mathematics instruction strategies and attitudes.

Teachers' perceptions about their practice were analyzed using a twenty item survey (see Appendix A) which offered ten items related to their mathematics instruction strategies and ten items related to their attitudes about mathematics. Nineteen of the statements used a Likert Scale, and one was a free response item.

The quantitative data analyzed, the mean (see Appendix C), the range (see Appendix D), and the percent of change (see Appendix E and F) of the Likert Scale scores, provided evidence that supported improved student learning through the use of the differentiated, hands on mathematics instruction strategies.

The compared mean scores of the pre and post survey (see Appendix C) showed positive increases in teachers' responses to selective statements related to pedagogy. This evidence of enhanced differentiated, hands on mathematics instruction strategies and attitudes resulted in improved student learning.

Pre-survey responses to statements that related to teachers' mathematics instruction strategies (see Appendix C) revealed telling evidence that they relied on passive, antiquated, and rote mathematics instruction strategies prior to the action research. This was identifiable by their responses which yielded high mean scores to specific negative statements related to their pedagogy: (1) I teach lessons straight from the textbook. (2) Students learn best when taking notes during a lesson. (3) I usually teach by writing notes and examples on the board. Some responses yielded low mean scores to specific positive statements about pedagogy revealing the same message: (1) I use manipulatives to teach mathematical concepts. (2) I teach through differentiated instruction.

The post-survey responses to these same statements that related to teachers' mathematics instruction strategies (see Appendix C) identified positive changes. Mean scores increased following the action research and the implementation of the enhanced strategies. Positive increases in the percent of change (see Appendix E) for these items ranged from 10% to 31%.

The compared mean scores of the pre and post survey (see Appendix C) showed positive increases in teachers' responses to selective statements related to attitudes about mathematics. Improved teachers' attitudes fostered environments conducive to improved student learning.

The pre-survey responses to statements related to attitude about mathematics (see Appendix C) revealed that some teachers had a poor predisposition about mathematics and how it related to themselves and their students. Some negative pre-survey statements which yielded some unanticipated high mean scores were: (1) All I learned about teaching math I learned in college. (2) Math is a stagnant subject; it never changes. (3) I enjoy math because it is logical. (4) Some students have an aptitude in math and are just better at it. The survey had a free response item which asked teachers to supply three adjectives that would describe their instruction. These responses echoed the same sentiment: repetitive, practical, orderly, thorough, continuous.

The post-survey responses to these same statements that related to teachers' attitude about mathematics were energizing. Mean scores (see Appendix C) increased following the action research and the implementation of the enhanced mathematics instruction strategies. The improved instruction was enlightening and empowering to teachers and their students. Positive increases in the percent of change (see Appendix E) for these items ranged from 11% to 56%.

The most enriched data that supported improved student learning was the qualitative anecdotal data from excerpts of teachers' reflective journals (see Appendix B). These reflections and observations provided examples of specific learning outcomes that took place within the classroom. These learning outcomes could not have been measured or even identified through traditional mathematics instruction strategies.

Through the implementation of differentiated, hands on mathematics instruction strategies teachers were able to actively engage their students in mathematics yielding improved instruction and student learning. They provided alternative experiences which piqued their students' interest and allowed for mathematical application and synthesis in practical problem solving situations. This innovative instruction allowed for improved student learning by providing discovery within the classroom. Teachers facilitated this learning by creating a sense of empowerment within their students. This empowerment, intrinsically motivated students to look at mathematics globally and changed their perception of what mathematics means to them.

Conclusion

The triangulation of the data the research instruments provided showed positive growth through student scores, teachers' mathematics instruction strategies and attitudes, and observation of learning which were identified within reflective journal excerpts. The study concluded that students in grades six through eight at the G.S. School are better prepared to apply mathematical concepts to problem solving situations.

Chapter 5

Conclusions, Implications and Further Study

Introduction

It is no secret to educators that quality instruction yields a quality education. However within this understanding educators must take into account the needs of individuals within their classrooms and assure that all students are receiving the same high level quality instruction. Individualized quality instruction will produce specific outcomes for every student, but all students will not produce the same outcome. This action research study looked at how teachers who wanted to provide high quality individualized instruction improved student learning through the implementation of differentiated, hands on mathematics instruction strategies.

Grand Tour

The study focused on the improvement of instruction through the development and implementation of differentiated, hands on mathematics instruction strategies to improve student learning. Dedicated teachers spent countless hours identifying standards of mathematics instruction at their grade levels. Then they developed lessons, through research and creativity, and implemented them to meet the needs of the standards. This action created a sense of empowerment and excitement within the teachers that ultimately trickled down into the classroom. Although the district did not provide time and resources for these teachers, they still facilitated their own action for the improvement of instruction.

Implications of Study on Leadership Skills

The study relied on an educational leader who promoted the success of students by facilitating the professional growth of teachers so they were able to develop and implement differentiated, hands on mathematics instruction strategies to improve the students' application of mathematics towards experiential, problem solving situations. The educational leader provided teachers the initiative, organization, and materials for action research to occur among their colleagues in a safe and meaningful environment.

Implications of Study on Organizational Change

Literature and research offer the necessary components needed for meaningful differentiated, hands on mathematics instruction strategies to improve student learning. The NCTM has provided curriculum and evaluation standards for mathematics instructors to attain. Situations of successful differentiated, hands on mathematics instruction are becoming more common. The methods to create these successful situations have come from zealous mathematics teachers who have been properly trained and have a commitment to these revolutionary teaching and classroom management strategies. These strategies of instruction enable students the freedom to explore and discover mathematical concepts while using a variety of processes and manipulatives. How to attain these successful teaching situations will be an individual journey for each educator unless district administrators mandate change. If districts supply the resources for teachers to engage in action research on a regular basis, instruction improvement in all disciplines would benefit. In light of federal law mandating annual yearly progress, professional development should be geared directly towards the improvement of instruction.

Further Study

Action research where teachers may research, develop, and implement meaningful lessons in their classrooms to meet the individual needs of their students should become a norm of our schools, and not the exception. This study provided the initiative for a core group of mathematics teachers to complete professional development in order to provide their students with much needed differentiated, hands on mathematics instruction strategies for improved problem solving. The study, if adopted throughout the entire pre-K through 8^{th} grade district, would be beneficial on many fronts. A school or district wide initiative on developing and implementing differentiated, hands on mathematics instruction strategies for improved problem solving would:

1. Set meaningful teacher and student expectations.
2. Allow grade levels to meet national and state mathematics standards.
3. Allow teachers, through action research and collaboration, to develop and create a wide variety of problem solving lessons and materials that could be shared.
4. Provide opportunities for teachers to work together to create comradeship and improve morale.
5. Allow teachers to gain regular feedback about their teaching practices from their peers in a safe environment.
6. Allow for articulation throughout the school creating a continuum of problem solving learning.
7. Provide action research opportunity, where teachers would gain invaluable professional development that would meet state and federal mandates for becoming a highly qualified teacher.

8. Provide cost effective professional development opportunities.
9. Provide excellent mathematics instruction that could provide cross curricular opportunities.
10. Provide meaningful experiences that teach concepts students should learn while teaching them how to learn.

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Appendix A

Research Instrument: Survey

Mathematics Instruction Survey

Please complete the following survey. This will allow me to gain some information about your teaching strategies and attitudes in mathematics. Please circle the appropriate response and return the survey to Mr. Cetrullo. Thank you for your cooperation.

1 Strongly Disagree 2 Somewhat Disagree 3 Neutral 4 Somewhat Agree 5 Strongly Agree

I enjoy working with my hands to solve problems. 1 2 3 4 5

All I learned about teaching math; I learned in college. 1 2 3 4 5

I teach lessons straight from the textbook. 1 2 3 4 5

Students learn best when taking notes during a lesson. 1 2 3 4 5

I enjoy a quiet, orderly classroom. 1 2 3 4 5

Mathematics is a sequential discipline. 1 2 3 4 5

I usually teach by writing notes and examples on the board. 1 2 3 4 5

I use manipulatives to teach mathematical concepts. 1 2 3 4 5.

I have studied math instruction within the last 10 years. 1 2 3 4 5

I enjoy math because it is logical. 1 2 3 4 5

The best way to assess learning is through a written test. 1 2 3 4 5

I teach through differentiated instruction. 1 2 3 4 5

When teaching a new concept, it is important to give students as much information as possible.
1 2 3 4 5

Assigning many practice problems reinforces the day's lesson. 1 2 3 4 5

Some students have an aptitude in math and are just better at it. 1 2 3 4 5

I have studied math instruction within the past 5 years. 1 2 3 4 5

Math is a stagnant subject; it never changes. 1 2 3 4 5

Students discover math when I teach them. 1 2 3 4 5

Please supply three adjectives that would describe your mathematics instruction.

____

Appendix B

Research Instrument: Reflective Journal Excerpts

Reflective Journal Excerpts

Excerpts from teachers' reflective journals provided data which gave insight on teachers' mathematics instruction strategies following their action research. These excerpts were voluntarily shared as evidence to measure student learning.

9/10/03

Today I implemented the first hands on lessons. Their objective was to be able to work cooperatively to apply formulas of area (which they previously learned) to estimate the population of blades of grass within specific shaped areas using a square inch cut out, a yard stick, and a sheet with expectations and rules for students to follow. They were given only a simple explanation of the activity and were told to begin working. Initially the students were perplexed because I was not directing them and they had to communicate to create their plan. One group was instantly labeled the smart group because two very competent students were in that group, however they argued over whose plan they were going to use. Another group experienced complete dissention, relying on two individuals to create the plan and direct the others. It was a math activity, but I believe everyone received a lesson in group dynamics as well. Some students became enraged. It was great. Never did I see that kind of emotion about math in my classroom. One group, which had some poor traditional learners, yet were hands on learners, quickly identified a process to meet their needs. Students, who were normally followers, were now in a position of status and leadership. Normal leaders identified with being a follower, as the role reversals were evident. When groups realized their process, they were running a laughing as they measured and calculated. The activity called for specific results, written directions on how the estimate was accomplished. Some groups considered this the real work; however what I experienced gave me true insight into how specific students learn. This activity allowed some students, who normally don't get recognized as being mathematically capable, the opportunity to shine. We discussed this once we returned to class and most students recognized a little bit about what type of learners they are.

If we had more time it would have been great to allow the groups to chart their process and share how they came about it.

I was pleased at my ability to allow my students some freedom by stepping down from my role of directing and passing out information to one of facilitating action. This allowed for discovery on the parts of my students.

Students weren't behaving beyond my expectations. I knew they would run around and swing yardsticks. This was new for them and they have to get acquainted with the independence and freedom during math activities. Some even monitored themselves as I heard them say, "Hey, he's looking at us, knock it off," and "He's coming."

Personally I felt I was cheating them in some way because I was not supplying a traditional lesson and I was not the focus of their efforts, however I did supply an environment for their learning.

10/6/03

Silent structure is the name of the activity in which groups of students are asked to build a structure out of 36 inch wooden dowels which were to be connected with rubber bands at the ends. Students worked cooperatively to create a structure at least four feet tall that could house a student within standing totally erect. This had to be constructed without talking.

This was awesome. It was the first time my class followed all of the rules and directions perfectly. I think they are understanding the value of the activities and are now excited to participate. After the initial directions, of which I only said once, students began to work without me having to prompt them. Unlike other activities, where students were led in a direction I wished them to follow, the students worked using many different and unanticipated strategies. They were thinking, applying and synthesizing which displayed the higher order thinking skills. This was excellent proof of student learning through performance. The majority of the groups used geometric shapes which had been discussed previously. Two groups recalled that triangles were the strongest shape and incorporated that into their buildings. Some used primitive strategies of lean-to or post structures. The evaluation, following the lesson, identified the many cross-curricular aspects of the lesson as well as the mathematics concepts used.

This activity did not take as long. Shorter tasks seem to work better as this was the best lesson yet. It provided for great student focus and motivation. Students actually asked to do it again. When did students ever ask to complete a traditional lesson over?

11/24/03

Constructive chaos would best describe this tiling activity. Students were asked to work cooperatively to tile an area of nine square feet (three feet by three feet). They glued geometric shapes cut out of construction paper on to a larger sheet which simulated open floor space. They were prompted the previous day and asked to look at tiling in their environment, bathrooms, kitchens, school. They were told they could be moderately creative and would have to cover the entire floor area. Three of the four groups completed the task properly, however one group stood above the rest. Two groups instantly recognized that the entire pieces of construction paper covered the area quite nicely because the paper was 12" X 18" which are multiples of 36". The best group created tiles 6" X 6" and used 36 of them to cover the area. They incorporated many areas of math to complete this task and I was very excited about the results. During the closing discussion, every student had a great understanding of how this activity was very practical and could easily be used in their future.

Behaviorally this was the worst activity as I had to continually patrol for improper behavior. Students were cutting and pasting in every corner of the room and even overflowed into the hallway. Next time I should try to secure a larger space for the lesson.

12/11/03

Today the classroom was very noisy and chaotic, students were working independently with cubes to understand concepts of translations involving mirror images. We were finding methods of creating mirror images from specific base plans.

They constantly needed reinforcement from me or their peers. Then an amazing thing happened. A usually introverted and shy young man erupted when he successfully found an alternative method for making the image that had not been identified thus far. This reminded me of a video I had seen on Japanese students cooperatively working to solve problems in science and math. They, like my student, went beyond the assignment expectations. This was a true discovery, something that could never be relicated on a written assessment. Students have so much interest, it becomes fun, and they gain a greater understanding of a concept because they made a memory by relating it to an emotional experience.

1/7/04

My planning has become a huge undertaking. The differentiated, hands on mathematics instruction strategies are time consuming to create and plan. The work seems to be having the lesson ready to facilitate not the completion or assessment of the lesson.

1/23/04

Every experience seems to unfold a new twist. I have gotten to know my students on such a deeper level. These instruction strategies allow me to be hands on with smaller numbers of students. Since I spend less time with whole group instruction, I am able to be among my students more. I now have more time to better meet the needs of my students. I also engage in more casual conversation with my students, because during this group time much more than math is discussed. Students are continually making analogies to express their ideas. They are constantly relating math to topics they normally wouldn't associate math with. One may think this is unproductive and off task, and sometimes it may be, but the information I gain and the relationships I build ultimately help me to improve my instruction and student learning. I see this as being student centered and being a good thing. I gain greater understanding of who they are and apply that to my lessons therefore meeting individual needs.

Appendix C

Mathematics Instruction Survey:

Mean Scores of Survey Items:

Pre and Post Survey Results

Mean Scores of Survey Items: Pre and Post Survey Results

1 Strongly Disagree 2 Somewhat Disagree 3 Neutral 4 Somewhat Agree 5 Strongly Agree

	Pre	Post
I enjoy working with my hands to solve problems	3.2	3.6
All I learned about teaching math; I learned in college.	3.4	4.2
I teach lessons straight from the textbook.	4.2	3.6
Students learn best when taking notes during a lesson.	4.2	3.2
I enjoy a quiet, orderly classroom.	4.4	3.2
Mathematics is a sequential discipline.	4.2	3.8
I usually teach by writing notes and examples on the board.	4.2	3.4
I use manipulatives to teach mathematical concepts.	2.6	3.4
I have studied math instruction within the last 10 years.	3.2	5.0
I enjoy math because it is logical.	3.8	3.4
The best way to assess learning is through a written test.	3.6	2.8
I teach through differentiated instruction.	2.6	3.8
When teaching a new concept, it is important to give students as much information as possible.	3.6	3.2
Assigning many practice problems reinforces the day's lesson.	3.4	3.2
Some students have an aptitude in math and are just better at it.	4.2	3.2
I have studied math instruction within the past 5 years.	3.2	5.0
Math is a stagnant subject; it never changes.	3.2	2.2
Students discover math when I teach them.	4.0	4.6

Please supply three adjectives that would describe your mathematics instruction.

<u>Pre</u> – Repetitive, practical, orderly, thorough, continuous

<u>Post</u> – Engaging, student centered, fun, discovery based.

Appendix D

Range Scores of Survey Items: Pre and Post Survey Results

Range Scores of Survey Items: Pre and Post Survey Results
(Lowest score to highest score identified)

1 Strongly Disagree 2 Somewhat Disagree 3 Neutral 4 Somewhat Agree 5 Strongly Agree

	Pre	Post
I enjoy working with my hands to solve problems.	1 - 5	2 - 5
All I learned about teaching math; I learned in college.	2 - 4	4 - 5
I teach lessons straight from the textbook.	3 - 5	3 - 4
Students learn best when taking notes during a lesson.	4 - 5	1 - 5
I enjoy a quiet, orderly classroom.	4 - 5	1 - 5
Mathematics is a sequential discipline.	4 - 5	3 - 4
I usually teach by writing notes and examples on the board.	4 - 5	2 - 5
I use manipulatives to teach mathematical concepts.	1 - 4	2 - 5
I have studied math instruction within the last 10 years.	1 - 5	5
I enjoy math because it is logical.	3 - 4	2 - 5
The best way to assess learning is through a written test.	3 - 5	2 - 4
I teach through differentiated instruction.	1 - 4	3 - 4
When teaching a new concept, it is important to give students as much information as possible.	2 - 4	1 – 5
Assigning many practice problems reinforces the day's lesson.	2 - 5	1 - 5
Some students have an aptitude in math and are just better at it.	2 - 4	2 - 4
I have studied math instruction within the past 5 years.	1 - 5	5
Math is a stagnant subject; it never changes.	1 - 5	1 - 3
Students discover math when I teach them.	3 - 5	3 - 5

Appendix E

Survey Statements Grouped.

Statements of Mathematics Instruction Strategies:

Percentage of Change: Pre and Post Survey Results

Statements of Mathematics Instruction Strategies

	Percentage of Change: Pre/Post Survey
1. I teach lessons straight from the textbook	14% Agree Less
2. Students learn best when taking notes during a lesson.	24% Agree Less
3. Mathematics is a sequential discipline.	10% Agree Less
4. I usually teach by writing notes and examples on the board.	19% Agree Less
5. I use manipulatives to teach mathematical concepts.	31% Agree More
6. The best way to assess learning is through a written test.	22% Agree Less
7. I teach through differentiated instruction.	46% Agree More
8. When teaching a new concept, it is important to give students as much information as possible.	11% Agree Less
9. Assigning many practice problems reinforces the day's lesson. Students discover math when I teach them.	6% Agree Less
10. Students discover math when I teach them.	15% Agree More

Appendix F

Survey Statements Grouped:

Statements of Teacher Attitudes Related to Mathematics:

Percentage of Change: Pre and Post Survey Results

Statements of Teacher Attitudes Related to Mathematics

	Percentage of Change: Pre/Post Survey
1. I enjoy working with my hands to solve problems.	13% Agree More
2. All I learned about teaching math; I learned in college.	24% Agree More
3. I enjoy a quiet, orderly classroom.	27% Agree Less
4. I have studied math instruction within the last 10 years.	56% Agree More
5. I enjoy math because it is logical.	11% agree Less
6. Some students have an aptitude in math and are just better at it.	24% Agree Less
7. I have studied math instruction within the past 5 years.	56% Agree More
8. Math is a stagnant subject; it never changes.	31% Agree Less

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