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Implications of Differentiated Instruction on Student Attitudes

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This research examines the implications of a differentiated curriculum on four general factors of student attitudes: motivation, enjoyment of mathematics, value of mathematics, and self-confidence. It is quasi-experimental by design. The sample included the 73 students enrolled in the Algebra I course at Western Christian High School in Hull, Iowa. During the third quarter of the school year, students with eligible grades were allowed to contract out of portions of the regular assignment. Attitudes were measured before and after the quarter using the Attitudes Towards Mathematics Inventory (Tapia, 1996). A t-test was used to compare student attitudes. There were significant differences in individual groups pre-test to post-test, but no significant differences between the control class and the intervention classes. The only significant difference between contract and non-contract students was an increase in value of mathematics among contract students compared to a decrease among non-contract students. This is an important result as it has implications for encouraging high-achieving students to continue their study of mathematics.

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by

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Abstract

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Implications of Differentiated Instruction on Student Attitudes

Introduction

The purpose of this research was to examine implications of a differentiated curriculum on four general factors of student attitudes: motivation, enjoyment of mathematics, value of mathematics, and self-confidence. The goal of my research was to learn more about what motivates students to learn. God has created students in His image and yet they are all unique. Does a differentiated curriculum allow students more freedom to express their individual preferences and abilities? Does it improve student attitudes? Attitudes towards mathematics can often determine whether or not a student continues to study math or pursue careers involving mathematics. I wanted to know if alternate instructional strategies improved student attitudes and encouraged students to further their study of the quantitative and spatial aspects of God's creation.

Research Question

Does a differentiated curriculum that recognizes and allows students to use their God-given unique talents and abilities through the use of contracts, compacting and looping affect the enjoyment of mathematics, motivation, value of mathematics, or self-confidence of students?

Definition of Terms

The following definitions of terms are given to promote clarity throughout the study:

Compacting: Teachers identify curricular items that can be accelerated or eliminated to allow for more challenging or personally interesting curricular pursuits.

Differentiated Instruction: Teachers anticipate students' differences based on characteristics including interests, readiness, or learning style and vary students' acquisition of knowledge accordingly.

Instructional Looping: Students are allowed to "loop" in and out of instruction based on their need for it.

Learning Contracts: An agreement between the teacher and student about how a student chooses to meet the teacher's requirements.

Pathway Plans: Plans for managing assignments and tasks when looping.

Literature Review

In the traditional mathematics classroom, instruction is a 'one size fits all' approach. In an effort to not lose lower-achieving students, teachers often teach to the bottom and bore many students with greater mathematical ability. As a result, high-achieving students can learn to dislike mathematics because it appears slow, diluted, and repetitious to them. Boredom and a lack of personal meaning can also lead to behavior problems (Fennema, 1994). Others fear that "if interest [in gifted students] is snuffed out early, the talent may not be developed" (Johnson, 2000, p. 2).

Proverbs 22:6 states, "Train a child *in the way he should go* [italics added], and when he is old he will not turn from it" (Life Application Bible) . Notice that each child has his own way. God is telling us that not every student will have the same path; this includes each child's education. We need to make new paths for members of our communities who are gifted in mathematics so they can continue to use their God-given abilities.

God did not create all students with the same interests or abilities. Each child is a unique image-bearer of his Creator and varies in many ways including his or her learning style, motivation, reading ability, confidence and ever increasingly their background and cultural influences. I value differentiation because it is a great teaching technique that acknowledges students' uniqueness. It gives them an opportunity to express themselves and explore areas that intrigue them. "The curriculum must take into account that students, as unique images of God, need opportunities to learn and respond to what they learn in personally meaningful ways" (Van Brummelen, 2002, p.122). Differentiated instruction can be an avenue for talented students to express their individuality and an empowering way to teach. It gives students a sense of ownership for their learning; something I strive for in my teaching.

Differentiated instruction "enhances learning for all students by engaging them in activities that better respond to their particular learning needs, strengths, and preferences" (Heacox, 2002, p.1). It has become an increasingly popular method to reach more learners over the past decade. "By giving such choices…you foster responsible decision making about learning and provide for the range of learning styles, abilities and developmental levels, and interests in your class" (Van Brummelen, 2002, p. 140). The options given in differentiated instruction also "broaden the scope of a student's experience and unfold new interests" (Steensma & Van Brummelen, 1977, p. 35). Differentiated instruction can also "allow a student to identify and develop his aptitudes, his creativity, and his potential skills in a broad cross-section of God's creation" (Steensma & Van Brummelen, 1977, p.35).

The key person associated with differentiated instruction is Carol Ann Tomlinson. Tomlinson has written many books, produced videos, and given seminars on the topic. She suggests eight strategies for differentiating: compacting the curriculum, independent study, interest centers, tiered assignments where students are given different levels of assignments, flexible grouping, learning centers, adjusting questions given to students based on characteristics, mentorships where students are guided by an adult in a particular area, and learning contracts (Kiernan & Tomlinson, 1994). Not only are there eight different strategies for differentiating, there also are different combinations of strategies and ways of implementing each one. "Differentiated instruction has as many faces as it has practitioners and as many outcomes as there are learners" (Pettig, 2000, p. 14). This research will include several of the strategies suggested above.

A two-year study (Cass, Mortenson, Putney, & Tyler-Wood, 2000, paragraph 1) called Project Ga-GEMS (Georgia's Project for the Gifted Education in Math and Science) noted that students gifted in science and mathematics that received differentiated instruction reported significantly higher total scores and scores in mathematics. So it has been proven that differentiation can improve the scores of high achieving students, but what about attitudes?

A study was performed in Arkansas to test if attitudes towards mathematics could be improved by enriching the curriculum. The research focused on girls and a control group was used. The girls were given a pre-test and post-test to measure their attitudes towards mathematics. The results revealed a significant improvement among the girls in the intervention with the enriched curriculum compared to the girls in the control group.

Attitudes and motivation play a major role in achievement. “As with most students, but particularly with gifted learners, the key to motivation is interest” (Heacox, 2002, p. 138). Mathematically gifted students (Johnson, 2000) have different needs in the classroom than others do. One study noted that in mathematics, targeted students had as much as fifty percent of the regular curriculum eliminated, yet still scored higher on the post-test than non-targeted students (Reis & Renzulli, 1992).

Regular instruction is often not challenging and can turn gifted students off to mathematics. “Offering choices is an important way to motivate students and get them interested in a project” (Heacox, 2002, p. 101). A differentiated curriculum can allow students to personalize their learning. Students can choose a project that relates to their lives or is interesting to them. When students can connect their learning to concepts that they already know, they learn more and it is more meaningful to them. This research offers students choices in their learning. Students can individualize their learning to meet their own needs or interests. Heacox found in her work that “many students welcome the opportunity to “test out” and earn the right to choose alternative pathways projects” (Heacox, 2002, p. 102).

This research will give mathematically gifted students the opportunity to be challenged and explore areas of interest. Differentiated instruction gives students an opportunity to be successful (Small, 1997). They can go beyond their daily work and choose a contract to excel in. It also allows students to avoid the unnecessary rigor and repetition of the traditional mathematics classroom. The intended outcome of these choices was improved student attitudes and motivation.

Methods

Participants

The participants in this study were three sections of Algebra I at Western Christian High School in Hull, Iowa. The participant make up was largely homogeneous in terms of age, ethnicity, and background. Generally, students were middle class, Caucasian, ninth graders in a rural setting. Algebra I was one of three options that students chose upon entering high school. For the 2004-2005 school year, five of the 83 students were enrolled in a basic Algebra class (6%), 72 were enrolled in Algebra I (87%), and 6 were in Geometry (7%). There was also one junior taking the class.

The intervention was performed on two of the three classes with the third class being a control. Students were randomly assigned to one of three sections according to their class schedule by the school guidance counselor. When I chose classes for the intervention, I selected the classes that I felt were the most interested in contracts and had the most eligible students. In order to be eligible to sign a contract, students needed a grade of B or above. Of the 52 students in the intervention classes, 45 students held grades which made them eligible to sign a contract and of those 27 chose to sign contracts.

Materials

The materials necessary to carry out the intervention consisted of activities for students to pursue in their contracts. Twenty-three different worksheets were offered throughout the quarter as possible options. These worksheets came from the textbook, magazines, mathematical workbooks, and things that I had put together myself. Appendix A is an example of a popular choice for students. Students also had the option

to write a report. They were given a list of possible report topics (Appendix B), but were not limited to the list.

Procedure

The design of the research was quasi-experimental as the sections were created prior to the study. It was a non-equivalent, control group design; a class of students was used as the control group. A letter was sent to the parents of students in all classes explaining the procedure (Appendix C). The independent variable was differentiated instruction in the form of compacting, contracting, and looping. The dependent variable was student attitudes.

Student attitudes were measured by the Attitudes Towards Mathematics Inventory (ATMI - Appendix D). The ATMI was examined with 545 secondary students at all levels and topics in the mathematics curriculum. Internal consistency had a reliability coefficient alpha of 0.97. A varimax rotation yielded four factors of content validity: self-confidence, value of mathematics, enjoyment of mathematics, and motivation (Marsh & Tapia, 2004). Students respond using a Likert scale with responses ranging from strongly agree to strongly disagree. Eleven questions are reversed and need to be given the appropriate weight when scored. Sample questions for each factor include the following:

- Self-confidence

I am able to solve mathematics problems without too much difficulty.

- Value of mathematics

Mathematics is important in everyday life.

- Enjoyment of mathematics

Mathematics is a very interesting subject.

- Motivation

The challenge of math appeals to me.

I performed a pilot study with the ATMI two weeks prior to the beginning of the intervention with a group of 20 eighth grade students. No adjustments to the instrument were necessary.

The experiment took place in the third quarter, during three of the thirteen units taught throughout the year. The ATMI was administered to the three Algebra I classes prior to the experimental phase on January 13, 2005 (pre-test) and again at the close on March 17, 2005 (post-test). Students were given an identification number to record on their instrument. This allowed tracking of responses while giving students anonymity.

The control class carried on as usual. In the intervention classes, students with grades of A or B had the option to compact the curriculum by signing a green or blue contract at the beginning of the chapter (Appendix E). Students who signed a contract were allowed to loop in and out of class lectures. As soon as they felt that they understood a concept, they began their assignment. A green contract was available to students who had an average grade of A- (92%) or higher. A blue contract was available to students who had an average grade of B (85%) or higher. A green contract allowed a student to omit all odd problems from assignments and a blue contract allowed students to omit every third problem.

In exchange for shortened assignments and lectures, students who signed a contract chose a project to work on throughout the chapter. Examples of projects available to students are computer labs, calculator labs, Internet explorations, individual studies, peer tutoring, and mathematical explorations. Possible topics include game

theory, number theory, problem solving, statistics, probability, and business applications. Students also had the choice to propose a project of their own design.

At the end of each chapter, students who chose to compact were graded like the rest of the class. Their project was graded with a rubric and replaced the portion of the homework that they were not required to complete (Appendix F).

Results

Data Analysis

Difference scores were used to analyze the results of the ATMI. The pretest score was subtracted from the posttest score for each of the four factors to reveal a difference score. The difference score was a positive number for students whose attitude increased and a negative score for students whose attitude decreased. The mean and standard deviation of the scores was calculated and reported for each factor included in the instrument. Students were separated into categories for comparison. Categories were the whole group, the intervention group, the control group, students who signed contracts, students who did not sign contracts, students with grades of A- and above, students with grades of B and above, and students with grades below B.

An independent, 1-tailed t-test was used to show significant differences between groups and pre-test and post-test scores. An alpha level of $p<.05$ was used to show significance. Any probability less than .05 suggests that the likelihood of that outcome randomly happening would occur less than 5% of the time. Thus, for results less than .05 we reject the null hypothesis and accept that the intervention has had an effect on the results.

Findings

Students could sign a maximum of three contracts throughout the quarter. Figure 1 illustrates the number of times eligible students chose to contract. A majority chose to contract only one time. Some students found it difficult to get their work done on time, and preferred daily assignments. Other students' grades dropped making them ineligible to participate.

Figure 1: Number of Contracts Signed Per Student

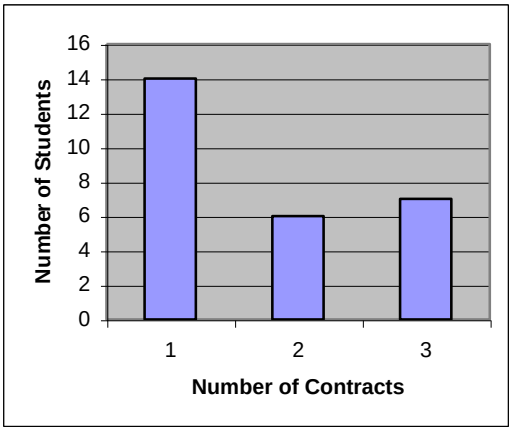

Figure 2 gives the mean pre-test and post-test scores of all three sections for the ATMI. The total average pre-test score was 3.336 and the total average post-test score was 3.278.

Figure 2: Whole Class Mean Pre-Test and Post-Test Scores

Self-Confidence		Value		Motivation		Enjoyment		Total	
Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
3.474	3.378	3.790	3.807	2.996	2.855	3.085	3.075	3.336	3.278

The whole class mean difference scores are given in Figure 3. There were slight increases in value and enjoyment, but greater drops in self-confidence and motivation.

Figure 3: Whole Class Mean Difference Scores and Standard Deviations

	Self-Confidence	Value	Motivation	Enjoyment	Total
Mean	-0.097	0.016	-0.141	0.010	-0.058
Standard Deviations	0.539	0.461	0.571	0.577	0.540

Figure 4 shows the significance levels of the above changes using a t-test to compare pre-test scores to post-test scores. The percentage of significance is given and all changes within the 5% significance level are noted in bold throughout the paper. Since an alpha level of 5% has been chosen, any probability equal to or less than 5% is considered significant. Consequently, we reject the null hypothesis and assume that the intervention had an effect. The only significant change for the whole class was a drop in motivation. It is likely that this drop has more to do with the typical third quarter slump than the intervention performed, since it was a significant finding for the whole class.

Figure 4: Whole Class Significance Probabilities

Self-Confidence	Value	Motivation	Enjoyment	Total
0.065	0.381	**0.019**	0.440	0.226

Tables 1 and 2 in the appendix give the pre-test and post-test scores for each student. They are divided into contract and non-contract students. The mean of these pre-test and post-test scores are given in Figure 5. Scores are fairly similar for each group. The non-contract students scored lower in all groups on both the pre-test and the post-test. All factors had drops with the exception of "value" for the contract students and "enjoyment" for the non-contract students.

Figure 5: Contract and Non-Contract Mean Pre-Test and Post-Test Scores

	Self-Confidence		Value		Motivation		Enjoyment	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Contract	3.812	3.691	3.883	4.015	3.341	3.189	3.328	3.281
Non-Contract	3.276	3.193	3.736	3.685	2.793	2.659	2.942	2.953

Individual difference scores for contract and non-contract students are given in Tables 3 and 4 in the appendix. The mean difference scores and standard deviations are given in figure 6. Deviations were greater for students in the non-contract group than those in the contract group. The total standard deviation for contract students was .406 compared to .606 for non-contract students. This may be due to the more homogeneous make up of students in the contract group. Students in this group had similarities of high grades and a willingness to try something different.

Figure 6: Contract and Non-Contract Mean Difference Scores and Standard Deviations

			Difference Scores		
	Self-Confidence	Value	Motivation	Enjoyment	Total
Contract	-0.121	0.131	-0.152	-0.046	-0.047
Non-Contract	-0.082	-0.051	-0.135	0.011	-0.064
			Standard Deviations		
	Self-Confidence	Value	Motivation	Enjoyment	Total
Contract	0.394	0.364	0.436	0.390	0.396
Non-Contract	0.605	0.501	0.642	0.666	0.604

The table in figure 7 shows the comparison of pre-test to post-test scores for contract students and non-contract students using a t-test. Contract students had an increase of the value of mathematics, which is an important result. They had a decrease in

motivation, but it should be noted that non-contract students' motivation probability was also close to significant at 8.1%.

Figure 7: Contract and Non-Contract Significance Probabilities

	Self-Confidence	Value	Motivation	Enjoyment	Total
Contract	0.061	**0.036**	**0.041**	0.271	.102
Non-contract	0.183	0.247	0.081	0.456	.242

Figure 8 shows the significance levels of t-tests comparing contract students to non-contract students. The difference scores for the total score, self-confidence, motivation, and enjoyment were very similar for both groups with the exception of the value of mathematics. Contract students reported an increase of .131 compared to non-contract students drop of -.051, a difference of .182. An increase in the value of mathematics among contracting students gives strong support for differentiation.

Figure 8: Significance Probabilities of Contract to Non-Contract

Self-Confidence	Value	Motivation	Enjoyment	Total
0.373	**0.039**	0.447	0.322	0.384

The intervention groups were also compared to the control group. The average pre-test and post-test scores for the intervention groups and the control group is given in Figure 9. It is interesting to note that the control group scored substantially lower than the intervention group on both the pre-test and the post-test of attitude scores. The ATMI reaffirmed my choice of classes to use for the intervention.

Figure 9: Intervention and Control Groups Mean Pre-Test and Post-Test Scores

	Self-Confidence		Value		Motivation		Enjoyment	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Intervention	3.382	3.231	3.781	3.790	2.913	2.817	3.015	3.014
Control	0.182	0.166	0.211	0.220	0.172	0.148	0.170	0.156

The average difference scores and standard deviations for the intervention group and control group are given in Figure 10. Difference scores and standard deviations were quite similar; however the intervention group systematically scored lower in difference scores.

Figure 10: Intervention and Control Groups Mean Difference Scores and Standard Deviations

			Difference Scores		
	Self-Confidence	Value	Motivation	Enjoyment	Total
Intervention	-0.16	-0.004	-0.131	-0.084	-0.095
Control	0	0.005	-0.034	0.025	-0.001
			Standard Deviation		
	Self-Confidence	Value	Motivation	Enjoyment	Total
Intervention	0.515	0.439	0.583	0.482	0.350
Control	0.599	0.637	0.596	0.768	0.508

Figure 11 gives the significance levels for pre-test and post-test scores for students in the intervention and control groups. Self-confidence was the only item with a significant change. Some of the drop in self-confidence can be attributed to students who are in the intervention class, but whose grades are not high enough to participate. Being in the class, I did hear some of these students make remarks about how they were not smart enough to participate. This is definitely a concern of differentiation. If it has

positive effects for higher achieving students, but is harmful to the lower achieving, we need to proceed carefully because every student is made in God's image regardless of the intellectual ability. It must be noted that contract students had a difference score of -.121 compared to a drop of -.082 for non-contract students. I think a greater factor in the drop of self-confidence for the intervention groups was that contract students were being challenged more than they normally were in the classroom. They were given work that was more difficult than average and expected to complete it largely on their own which likely tested some students' confidence. Another factor in the drop of self-confidence may be the nature of the curriculum in the third quarter. There is increasingly less review of previously learned material and more introduction of new concepts.

Figure 11: Intervention and Control Groups Significance Probabilities

	Self-Confidence	Value	Motivation	Enjoyment	Total
Intervention	**0.015**	0.475	0.056	0.108	.164
Control	0.496	0.453	0.186	0.307	.361

The intervention group was also compared to the control group using a t-test. The results are given in figure 12. No significant differences were shown between the two groups.

Figure 12: Significance Probabilities of Intervention to Control Group

Self-Confidence	Value	Motivation	Enjoyment	Total
0.148	0.447	0.47	0.178	0.128

Figure 13 gives the difference scores and standard deviations of the class divided by their grade at the beginning of the quarter. Students were divided into A- and above

which correlates with students eligible for green contracts, B and above, or blue contracts, and B- and below. Difference scores were relatively stable; however, the B and above group had the greatest losses overall.

Figure 13: Students Mean Difference Scores and Standard Deviations by Grade

	Self-Confidence	Value	Motivation	Enjoyment	Total
A- and up	-0.042	0.097	-0.082	-0.003	-0.008
B and up	-0.184	-0.085	-0.196	-0.159	-0.156
B- and below	-0.009	-0.018	-0.218	0.282	0.009
Standard Deviation	Self-Confidence	Value	Motivation	Enjoyment	Total
A- and up	0.557	0.467	0.591	0.379	0.499
B and up	0.510	0.400	0.365	0.554	0.457
B- and below	0.484	0.533	0.812	1.023	0.713

Figure 14 shows the significance levels associated with pre-test to post-test changes for each grade category. The only significant changes were for the B and up group. They had a significant drop in self-confidence and motivation.

Figure 14: Significance Probabilities by Grade

	Self-Confidence	Value	Motivation	Enjoyment	Total
A- and up	0.323	0.103	0.199	0.483	0.277
B and up	**0.049**	0.160	**0.009**	0.092	0.077
B- and below	0.476	0.456	0.197	0.191	0.330

Discussion

Summary

To summarize this research, the most valuable finding in support of differentiation is an increase in the value of mathematics among students who chose to contract. The positive effects of differentiation also seemed to be greater for students with

grades of A- and above compared to students with grades of B and above. Overall, the *whole class had no significant changes with the exception of a drop in motivation.*

Conclusions

After my research and experiences, I believe that differentiated learning is a worthwhile teaching strategy. It treats students as unique image-bearers with unique interests.

Differentiation, in the form I implemented it, was a valuable teaching tool for the highest-achieving students. I wanted as many students as possible to have the chance to participate when I designed this research; however, it became clear to me that students with grades of B's and B+'s did not benefit from the quarter as much as the students with A- and above grades did. After my experience differentiating, I can see that contracting is not as beneficial for these students. The students with B's are good students with good grades, but differentiating their curriculum hurt them more than it helped them. Many of their grades dropped while they contracted, and they were not as capable of independently completing contract projects.

In the future, I will only use the green contract for the students with grades of A- and above. This type of differentiation has the best outcomes among the highest-achieving students and was the most beneficial for them. By raising the eligibility requirement, fewer students will be able to participate. I think this would lessen some of the negative feelings of students who were not eligible since a smaller percentage of the class would be involved in differentiating. By only including the highest-achievers, I think that I would better meet the needs of all students.

An added benefit of raising the eligibility requirement is that it will be easier to serve a smaller number of students more effectively. One of the challenges of differentiation is the amount of organization and multi-tasking that it takes on the teacher's part. Limiting the number of students may alleviate the large amount of supervision, guiding, grading, and organization; thus making it a more appealing teaching strategy.

Implications

The implications of this study are valuable for the field of mathematics education. A study relating differentiated instruction and student attitudes is important for many reasons. First, understanding this relationship helps teachers create classrooms in which learners are served in a more meaningful manner. In differentiated learning, mathematically gifted students can be challenged to expand and develop their abilities. Second, it lays a foundation upon which other areas of mathematics, as well as other subjects, can be differentiated in this way. Teachers in other areas can learn from my successes and failures to improve instruction in their classroom. Third, this research gives rationale for other strategies of differentiation in the mathematics classroom beyond compacting, contracting, and looping. Finally, this research confirmed that differentiation improved the value of mathematics for high achieving students. This is the first step in analyzing how we can better meet high-achieving students needs and encourage them in their study of mathematics.

Limitations

A possible limitation to this study could be the optional nature of the differentiation. Students were not forced to participate. Some students who were excellent candidates for differentiating chose not to. This could have skewed the results.

Another limitation is the natural variations that exist from class to class. Each year and even each class has its own personality. This study is limited to a single year and three classes. I think that it would be very interesting to repeat this study in another year with different classes to see the similarities and differences in the results.

A final limitation is the timing of the study. I believe that some of the results were compounded by what was going on in the curriculum or the school calendar. My largest concern for this would be the drop in motivation. In my experience teaching, I think that it is typical for students' motivation to wane during the spring. It is possible that the result of a drop in motivation has little to do with the intervention, but simply captured a natural phenomenon of spring.

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APPENDIX A

Sample Contract Option

Problem Solving Worksheet

1. There are seven people in a room. Each person shakes hands with each of the other people once and only once. How many handshakes take place?

2. To get to school Rosa must walk 8 blocks from her home: 5 blocks east and 3 blocks south. How many different routes can she take if there are streets at every block? (Rosa never back tracks, her route is always 8 blocks long.) Can she take a different way to school every day of the month? Year? Explain.

3. On the morning of the fourth of July a firecracker exploded and scared a frog into a cistern that was 21 feet deep. The frog began to climb out of the cistern. He made it up 3 feet by nightfall. The next morning, he discovered that he had slid back 1 foot during his sleep. He continued on satisfied with his pattern 3 feet upward during the day, and 1 foot downward at night. Finally he made it to the top. What was the date?

4. Fourteen clothespins are placed on a line at 7-foot intervals. How far is it from the first clothespin to the last?

5. The new school has exactly 100 lockers and exactly 100 students. On the first day of school, the students meet outside the building and agreed on the following plan: The first student will enter the school and open all of the lockers. The second student will then enter the school and close every locker with an even number (2, 4, 6,…). The third student will then "reverse" every third locker. That is, if the locker is closed, he will open it. If the locker is opened, he will close it. The fourth student will reverse every fourth locker, and so on until all 100 students in turn have entered the building and reversed the proper lockers. Which lockers will finally remain open?

6. Three boys stood on a scale and put a nickel in the slot. The scale showed 390 pounds as their total weight. One boy stepped off the scale. It then showed 255 pounds. The second boy stepped off the scale and it showed 145 pounds. Find the weight of each boy.

7. A major hamburger chain sold 22 million hamburgers, each 1-inch thick. If we stacked these hamburgers, how many miles high would the stack be?
(Hint: 5280 feet = 1 mile)

8. Find the sum of the counting numbers from 1 to 75 without using a calculator.

APPENDIX B

Possible Report Topics

Feel free to suggest your own. Make sure that Mrs. Z approves it first.

Green reports should be 2 pages

Blue reports should be 1.5 pages

Research and write a report on:

Fibonacci Numbers
Coding
The Babylonian Numeration System
Magic Squares
Pi
The History of Zero
Abundant, Deficient and Perfect Numbers
The history or uses of the Pythagorean Theorem
The relationship between music and mathematics
The BASIC computer programming language
Guillaume Gosselin and *De Arte Magna*

Research and write a report on one of these mathematicians' contributions to mathematics:

Plato
Pierre de Fermat
Johann Friederich Carl Gauss
Pythagoras
Eratosthenes and the Sieve of Eratosthenes
Archimedes
Liu Hui
Chevalier de Mere
Isaac Newton
Nicholas Copernicus
Blaise Pascal
Leonhard Euler
Girolamo Cardano
Rene Descartes
Francois Servois
Diophantus
Archimedes
Al-Khowarizmi

APPENDIX C

Parent Letter

Dear parents,

I trust that this finds you enjoying the New Year. I would like to let you know about some upcoming changes in your son or daughter's class work. Currently, I am completing coursework through Dordt College for my Master's Degree in Education. As a requirement of this, I am enrolled in ED 590 and have chosen to do action research on differentiated instruction.

This is where your son or daughter may be involved. During the third quarter, I will be offering to two of the three Algebra I classes the option to differentiate. Students in these classes may choose to pursue other areas of mathematics. At the beginning of a unit, students may sign a green or blue contract. Students who sign a contract are allowed to "loop" in and out of class lectures. As soon as they feel that they understand a concept, they may begin on their assignment.

Green Contract:

- Available to students who have an average grade of A- or higher
- Allows students to omit all odd problems from assignments

Blue Contract:

- Available to students who have an average grade of B or higher
- Allows students to omit every third problem

In exchange for shortened assignments and lectures, these students will choose a project to work on throughout the unit. Examples of projects available to students are computer labs, calculator labs, Internet explorations, individual studies, peer tutoring and

mathematical explorations. Possible topics include game theory, number theory, architecture, statistics, probability, business applications, and others. Green student projects will be expected to be slightly more in depth as they are doing less of the regular assignment than blue students.

As mentioned before, this is completely optional. No student is forced to participate; however, I would love to see many try. The purpose of my research is to examine student attitudes. Your student will take a brief survey prior to the quarter and after the quarter through which I will be looking for changes in motivation, enjoyment of mathematics, value of mathematics, and self-confidence. Examples of contracts and guidelines are on Western's website. I strongly believe that the education given to all students will be enhanced by this strategy. If you have any questions or concerns please call or e-mail. I hope the quarter goes well!

Mrs. Valorie Zonnefeld

439-1579

ryvalzon@hotmail.com

APPENDIX D

Attitudes Towards Mathematics Inventory

Directions: This inventory consists of statements about your attitude toward mathematics. There are no correct or incorrect responses. Read each item carefully. Please think about how you feel about each item. Darken the circle that most closely corresponds to how the statements best describe your feelings. Use the following response scale to respond to each item.

PLEASE USE THESE RESPONSE CODES:
1 – Strongly Disagree
2 – Disagree
3 – Neutral
4 – Agree
5 – Strongly Agree

Circle your responses for all 40 statements.

1 2 3 4 5	1. Mathematics is a very worthwhile and necessary subject.
1 2 3 4 5	2. I want to develop my mathematical skills.
1 2 3 4 5	3. I get a great deal of satisfaction out of solving a mathematics problem.
1 2 3 4 5	4. Mathematics helps develop the mind and teaches a person to think.
1 2 3 4 5	5. Mathematics is important in everyday life.
1 2 3 4 5	6. Mathematics is one of the most important subjects for people to study.
1 2 3 4 5	7. High school math courses would be very helpful no matter what I decide to study.
1 2 3 4 5	8. I can think of many ways that I use math outside of school.
1 2 3 4 5	9. Mathematics is one of my most dreaded subjects.
1 2 3 4 5	10. My mind goes blank and I am unable to think clearly when working with mathematics.

1 2 3 4 5	11. Studying mathematics makes me feel nervous.
1 2 3 4 5	12. Mathematics makes me feel uncomfortable.
1 2 3 4 5	13. I am always under a terrible strain in a math class.
1 2 3 4 5	14. When I hear the word mathematics, I have a feeling of dislike.
1 2 3 4 5	15. It makes me nervous to even think about having to do a mathematics problem.
1 2 3 4 5	16. Mathematics does not scare me at all.
1 2 3 4 5	17. I have a lot of self-confidence when it comes to mathematics
1 2 3 4 5	18. I am able to solve mathematics problems without too much difficulty.
1 2 3 4 5	19. I expect to do fairly well in any math class I take.
1 2 3 4 5	20. I am always confused in my mathematics class.
1 2 3 4 5	21. I feel a sense of insecurity when attempting mathematics.
1 2 3 4 5	22. I learn mathematics easily.
1 2 3 4 5	23. I am confident that I could learn advanced mathematics.
1 2 3 4 5	24. I have usually enjoyed studying mathematics in school.
1 2 3 4 5	25. Mathematics is dull and boring.
1 2 3 4 5	26. I like to solve new problems in mathematics.
1 2 3 4 5	27. I would prefer to do an assignment in math than to write an essay.
1 2 3 4 5	28. I would like to avoid using mathematics in college.
1 2 3 4 5	29. I really like mathematics.
1 2 3 4 5	30. I am happier in a math class than in any other class.

1 2 3 4 5	31. Mathematics is a very interesting subject.
1 2 3 4 5	32. I am willing to take more than the required amount of mathematics.
1 2 3 4 5	33. I plan to take as much mathematics as I can during my education.
1 2 3 4 5	34. The challenge of math appeals to me.
1 2 3 4 5	35. I think studying advanced mathematics is useful.
1 2 3 4 5	36. I believe studying math helps me with problem solving in other areas.
1 2 3 4 5	37. I am comfortable expressing my own ideas on how to look for solutions to a difficult problem in math.
1 2 3 4 5	38. I am comfortable answering questions in math class.
1 2 3 4 5	39. A strong math background could help me in my professional life.
1 2 3 4 5	40. I believe I am good at solving math problems.

 Student Number _____

Choose True or False:

TRUE FALSE I signed a contract to complete projects this quarter.

If you circled TRUE, circle the number of units you contracted for: 1 2 3

APPENDIX E

Sample Contract

Chapter 8 Blue Contract

I _____ contract to do all problems from assignments that are not multiples of 3. In exchange for shortened assignments, I will (choose one):

_____ Complete 6 of the 8 questions on the Problem Solving Worksheet.

_____ Do the graphing calculator exploration on the Golden Rule.

_____ Do the graphing calculator exploration on the probability of spaghetti pieces forming a triangle.

_____ Do the exploration of a Mortgage Broker examining loans.

_____ Analyze data about population characteristics.

_____ Do the worksheet on logic called Love Matches & on number theory called the Sieve of Eratosthenes

_____ Do the exploration Finite Differences that explores patterns and polygons.

_____ Write a 1.5 page report on _____. There is a sheet of possible report topics on the bookshelf.

_____ Explore _____ and demonstrate my learning by _____.

My project will be completed by _____.

Working Guidelines for Contracts

1. Stay on task at all times.
2. Do your daily assignment first, then your chosen activity.
3. Work quietly so that you do not disturb others.
4. If you need help while Mrs. Z is helping others, quietly ask someone else.

5. If you need to go to the library, quietly grab a slip, write down the time with a dry erase marker and show it to Mrs. Z before you leave.
6. The same guidelines apply in the library.
7. If you finish your project early, find something from the bookshelf to do.

I agree to the above conditions. I understand that if I do not follow them, I may lose the opportunity to continue with this contract.

Student's signature _____ Date _____

Approved: _____ Date: _____

APPENDIX F

Project Rubric

Place an X on the line that best represents your project.

Neatly Done	|_____|	Sloppy
Accurate	|_____|	Many Errors
Met Project Goals	|_____|	Missed Parts
I Understand	|_____|	I Don't Get It
Used Time Efficiently	|_____|	Inefficient
Worked Quietly Others	|_____|	Bothered

Green

For my overall project grade, I would give myself the following grade: _____

Mrs. Z's grade: _____ *1/2

Notebook grade: _____ *1/2

Total: _____

Blue

For my overall project grade, I would give myself the following grade: _____

Mrs. Z's grade: _____ * 1/3

Notebook grade: _____ * 2/3

Total: _____

TABLE 1

Pre-Test and Post-Test Scores for Contract Students

	Self-Confidence		Value of Math		Motivation		Enjoyment	
Student #	Pre	Post	Pre	Post	Pre	Post	Pre	Post
8201	4.600	4.267	4.000	4.200	3.200	3.300	3.400	3.400
8202	4.000	3.933	4.000	3.900	3.400	3.800	3.700	3.700
8204	3.933	3.867	3.800	3.900	3.400	3.000	3.600	3.600
8210	3.933	3.400	4.300	4.600	3.600	2.800	3.700	3.500
8213	3.933	3.800	4.400	4.200	3.400	3.400	3.900	3.500
8216	4.000	4.133	3.800	4.000	3.800	3.800	3.700	3.800
8217	3.333	2.400	3.450	3.300	2.600	2.000	2.400	2.350
8221	3.666	3.600	3.700	3.800	3.000	3.000	2.900	2.700
8223	3.733	4.666	4.000	4.000	3.600	4.600	3.300	3.400
8226	4.666	4.400	3.100	3.800	3.600	3.400	3.100	4.000
8230	3.666	3.400	4.200	4.200	3.200	3.200	3.100	2.900
8232	2.800	3.067	3.900	4.600	2.800	3.000	2.700	3.000
8239	4.000	4.067	3.700	3.600	3.400	3.400	3.000	3.000
8242	3.233	2.867	3.600	3.100	2.400	1.600	3.300	2.400
8246	2.867	3.200	4.000	4.400	2.800	2.600	2.500	2.900
8247	3.733	3.533	3.800	4.000	3.800	3.600	3.500	3.200
8248	4.600	4.600	4.000	4.700	3.800	4.400	3.600	3.700
8251	3.800	3.533	4.400	4.400	4.400	3.400	3.300	3.100
8252	4.000	3.267	4.300	4.500	3.800	4.000	3.700	3.600
8253	3.867	3.800	3.600	4.400	3.200	2.800	3.600	3.400
8256	3.467	3.467	4.000	3.100	2.400	2.000	3.100	2.300
8266	4.333	3.933	3.800	3.800	3.800	3.400	4.000	3.700
8268	4.433	4.333	4.400	4.600	3.800	3.800	4.450	4.150
8269	3.933	3.333	2.900	3.000	2.800	2.600	2.800	2.800
8272	2.067	1.933	3.000	3.100	2.800	2.800	2.100	3.000
8282	4.267	5.000	4.200	4.600	4.000	3.600	3.700	3.800
8285	4.067	3.867	4.500	4.600	3.400	2.800	3.700	3.700
Averages	3.812	3.691	3.883	4.015	3.341	3.189	3.328	3.281

TABLE 2

Pre-Test and Post-Test Scores for Non-Contract Students

	Self-Confidence		Value		Motivation		Enjoyment	
Student #	Pre	Post	Pre	Post	Pre	Post	Pre	Post
6233	2.267	2.867	3.000	2.900	2.200	2.800	2.700	3.200
8205	2.267	1.800	4.400	4.000	3.600	3.400	2.400	2.000
8206	3.133	3.600	4.400	4.800	3.600	3.200	3.600	3.800
8207	3.800	4.300	4.000	4.300	3.800	3.800	4.000	4.300
8208	3.267	3.067	2.800	2.900	2.000	2.200	2.500	1.900
8211	3.666	4.133	4.200	4.000	2.800	3.800	3.500	3.500
8214	3.067	2.666	3.200	2.200	1.600	1.200	2.300	1.600
8215	3.200	2.800	4.500	4.500	3.200	2.800	3.100	2.400
8218	3.867	4.600	3.200	4.400	2.400	2.600	2.600	4.600
8219	3.067	3.333	4.000	4.200	3.000	2.600	3.200	3.000
8222	3.533	3.933	3.800	3.900	3.200	3.200	3.500	4.000
8224	3.666	3.600	3.300	3.000	2.400	2.000	3.000	2.300
8225	2.467	2.000	3.200	2.900	2.800	1.200	1.700	1.600
8227	3.930	4.400	4.000	4.300	3.200	3.400	3.300	3.600
8228	3.400	3.133	3.900	3.100	2.200	1.600	3.000	1.900
8229	2.933	2.600	3.700	3.200	1.600	1.800	2.700	2.800
8231	4.000	3.133	4.000	3.800	3.400	3.600	3.600	3.700
8233	3.666	4.133	4.400	4.400	3.600	3.800	3.200	3.500
8234	3.933	3.567	2.400	2.700	2.200	1.600	1.700	1.700
8237	2.666	4.000	3.500	4.100	3.600	3.600	3.300	3.900
8238	4.133	3.400	3.200	3.000	2.400	2.000	3.100	2.900
8241	3.933	3.933	4.000	3.700	3.800	3.200	3.200	2.900
8243	1.733	1.933	3.400	3.400	1.400	1.000	2.200	2.700
8245	2.666	4.000	3.500	3.900	3.000	3.200	3.300	3.300
8249	1.800	1.133	3.300	2.400	2.200	1.200	2.800	2.000
8250	1.333	1.800	3.900	4.500	1.600	2.200	1.700	2.700
8254	3.933	2.500	4.100	4.100	2.300	2.800	3.200	2.700
8257	3.767	2.666	4.700	4.900	4.200	4.200	4.200	3.700
8258	3.267	3.400	4.600	4.500	2.400	2.200	2.500	2.600
8259	3.933	4.000	4.400	2.700	4.000	2.600	3.600	3.100
8260	4.867	4.067	4.100	4.100	3.000	3.200	4.300	3.500

8261	4.867	4.933	2.900	4.050	4.200	4.700	3.950	4.450
8263	4.133	4.600	3.200	3.400	2.400	3.600	2.800	3.100
8264	2.133	2.666	3.700	3.300	2.800	2.400	2.000	2.400
8265	4.400	4.067	4.000	4.050	4.400	3.400	3.800	3.700
8267	2.200	2.133	3.500	3.600	1.800	2.400	2.000	2.900
8270	3.666	3.666	4.100	3.600	3.200	3.400	3.500	3.900
8271	2.533	2.067	3.800	3.600	2.000	2.000	2.400	1.900
8273	3.067	3.533	3.400	2.900	3.000	1.800	2.300	3.100
8275	3.000	2.600	2.500	2.600	2.200	1.200	2.500	2.300
8276	4.067	3.533	4.100	3.800	3.400	3.200	3.800	3.300
8279	3.733	2.733	3.950	3.700	2.800	2.400	2.500	2.100
8281	2.333	1.267	3.000	3.000	2.400	2.000	2.200	1.800
8284	4.000	4.267	4.300	4.600	2.200	3.800	2.700	4.800
8286	3.267	2.600	4.400	4.700	3.200	2.400	3.400	2.800
8287	2.133	1.733	3.900	3.800	1.800	1.600	2.500	1.900
Averages	3.276	3.193	3.736	3.685	2.793	2.659	2.942	2.953

TABLE 3

Difference Scores for Contract Students

	# of	Self-				
Student #	Contracts	Confidence	Value	Motivation	Enjoyment	Total
8201	3	-0.333	0.200	0.100	0.000	-0.008
8202	3	-0.067	-0.100	0.400	0.000	0.058
8204	1	-0.067	0.100	-0.400	0.000	-0.092
8210	1	-0.533	0.300	-0.800	-0.200	-0.308
8213	1	-0.133	-0.200	0.000	-0.400	-0.183
8216	3	0.133	0.200	0.000	0.100	0.108
8217	1	-0.933	-0.150	-0.600	-0.050	-0.433
8221	1	-0.066	0.100	0.000	-0.200	-0.042
8223	2	0.933	0.000	1.000	0.100	0.508
8226	1	-0.266	0.700	-0.200	0.900	0.284
8230	2	-0.266	0.000	0.000	-0.200	-0.117
8232	2	0.267	0.700	0.200	0.300	0.367
8239	1	0.067	-0.100	0.000	0.000	-0.008
8242	1	-0.367	-0.500	-0.800	-0.900	-0.642
8246	1	0.333	0.400	-0.200	0.400	0.233
8247	3	-0.200	0.200	-0.200	-0.300	-0.125
8248	3	0.000	0.700	0.600	0.100	0.350
8251	2	-0.267	0.000	-1.000	-0.200	-0.367
8252	3	-0.733	0.200	0.200	-0.100	-0.108
8253	1	-0.067	0.800	-0.400	-0.200	0.033
8256	1	0.000	-0.900	-0.400	-0.800	-0.525
8266	2	-0.400	0.000	-0.400	-0.300	-0.275
8268	1	-0.100	0.200	0.000	-0.300	-0.050
8269	1	-0.600	0.100	-0.200	0.000	-0.175
8272	1	-0.133	0.100	0.000	0.900	0.217
8282	2	0.733	0.400	-0.400	0.100	0.208
8285	3	-0.200	0.100	-0.600	0.000	-0.175
Averages	27	-0.121	0.131	-0.152	-0.046	-0.047
Standard Deviations		0.394	0.364	0.436	0.390	0.279

TABLE 4

Difference Scores for Non-Contract Students

Student #	Self-Confidence	Value	Motivation	Enjoyment	Total
6233	0.600	-0.100	0.600	0.500	0.400
8205	-0.467	-0.400	-0.200	-0.400	-0.367
8206	0.467	0.400	-0.400	0.200	0.167
8207	0.500	0.300	0.000	0.300	0.275
8208	-0.200	0.100	0.200	-0.600	-0.125
8211	0.467	-0.200	1.000	0.000	0.317
8214	-0.401	-1.000	-0.400	-0.700	-0.625
8215	-0.400	0.000	-0.400	-0.700	-0.375
8218	0.733	1.200	0.200	2.000	1.033
8219	0.266	0.200	-0.400	-0.200	-0.033
8222	0.400	0.100	0.000	0.500	0.250
8224	-0.066	-0.300	-0.400	-0.700	-0.367
8225	-0.467	-0.300	-1.600	-0.100	-0.617
8227	0.470	0.300	0.200	0.300	0.318
8228	-0.267	-0.800	-0.600	-1.100	-0.692
8229	-0.333	-0.500	0.200	0.100	-0.133
8231	-0.867	-0.200	0.200	0.100	-0.192
8233	0.467	0.000	0.200	0.300	0.242
8234	-0.367	0.300	-0.600	0.000	-0.167
8237	1.334	0.600	0.000	0.600	0.634
8238	-0.733	-0.200	-0.400	-0.200	-0.383
8241	0.000	-0.300	-0.600	-0.300	-0.300
8243	0.200	0.000	-0.400	0.500	0.075
8245	1.334	0.400	0.200	0.000	0.484
8249	-0.667	-0.900	-1.000	-0.800	-0.842
8250	0.467	0.600	0.600	1.000	0.667
8254	-1.433	0.000	0.500	-0.500	-0.358
8257	-1.101	0.200	0.000	-0.500	-0.350
8258	0.133	-0.100	-0.200	0.100	-0.017
8259	0.067	-1.700	-1.400	-0.500	-0.883
8260	-0.800	0.000	0.200	-0.800	-0.350
8261	0.067	1.150	0.500	0.500	0.554
8263	0.467	0.200	1.200	0.300	0.542
8264	0.533	-0.400	-0.400	0.400	0.033
8265	-0.333	0.050	-1.000	-0.100	-0.346
8267	-0.067	0.100	0.600	0.900	0.383

8270	0.000	-0.500	0.200	0.400	0.025
8271	-0.467	-0.200	0.000	-0.500	-0.292
8273	0.467	-0.500	-1.200	0.800	-0.108
8275	-0.400	0.100	-1.000	-0.200	-0.375
8276	-0.533	-0.300	-0.200	-0.500	-0.383
8279	-1.000	-0.250	-0.400	-0.400	-0.513
8281	-1.066	0.000	-0.400	-0.400	-0.467
8284	0.267	0.300	1.600	2.100	1.067
8286	-0.667	0.300	-0.800	-0.600	-0.442
8287	-0.400	-0.100	-0.200	-0.600	-0.325
Averages	-0.082	-0.051	-0.135	0.011	-0.064
Standard Deviations	0.605	0.501	0.642	0.666	0.46133

Department of Education
Dordt College
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