

THE EFFECT OF USING A PROBLEM/PROJECT-BASED, DOCUMENT DRIVEN  
UNIT OF INSTRUCTION, ON HIGH SCHOOL STUDENTS' ACHIEVEMENT ON  
THE DATA ANALYSIS CLUSTER OF THE HSPA AND ON THEIR ATTITUDE  
TOWARD MATHEMATICS AND DATA ANALYSIS

A DISSERTATION

Submitted to the Faculty of  
Montclair State University in partial fulfillment  
of the requirements  
for the degree of Doctor of Education

by

JOY CUNNINGHAM BROKES

Montclair State University

Upper Montclair, NJ

2010

Dissertation Chair: Dr. Kenneth Wolff

Copyright © 2010 by *Joy Brokes*. All rights reserved.



## ABSTRACT

Joy Cunningham Brokes, Doctor of Education 2010

Major: Mathematics Pedagogy, Department of Mathematical Sciences

Title: The Effect of Using a Problem/Project-based, Document Driven Unit of Instruction, on High School Students' Achievement on the Data Analysis Cluster of the HSPA and on Their Attitude toward Mathematics and Data Analysis

Directed by: Dr. Kenneth Wolff, Department of Mathematical Sciences

## ABSTRACT

New Jersey's urban students traditionally don't do well on the high stakes NJ High School Proficiency Assessment. Most current remedial mathematics curricula provide students with a plethora of problems like those traditionally found on the state test. This approach is not working. Finding better ways to teach our urban students may help close this achievement gap. This study examined whether a problem/project-based data analysis unit incorporating the document features of the TI-Nspire would help students master data analysis concepts. The study used a quasi-experimental pre/Post-test design enhanced by a qualitative component. A four-week problem/project based data analysis unit served as the curriculum for the intervention treatment. Students were assigned either the TI-84 or the TI-Nspire calculator. Twelve sections of ninth grade students were divided into four basic study groups: (Intervention (TI-84), Traditional (TI-84), Intervention (TI-Nspire), and Traditional (TI-Nspire)).

The quantitative component of the study analyzed differences between students' pre/post- Total, Multiple-choice, Open-ended mean scores and quantified attitudinal responses. The analysis showed students in the TI-Nspire groups improved more on the Total test and Multiple-choice questions while students in the TI-84 group performed better on Open-ended questions. The Intervention Curriculum was more effective for Multiple-choice questions, Traditional Curriculum for Open-ended questions and Total scores. Student interviews revealed they didn't like taking notes and answering questions on the TI-Nspire. Some students liked referring to the information in the calculator while others felt that accessing information was too time consuming. The merits of the TI-Nspire document feature needs further exploration. Analysis of the quantified attitudinal survey showed an increase in the positive attitudes of students using the TI-Nspire.

Both qualitative and quantitative evidence showed the Traditional TI-84 group had fewer changes in attitude and content knowledge than everyone else combined, suggesting the need to change how we teach data analysis. Problem/project-based learning, if introduced gradually, may prove to be an effective teaching/learning educational practice.

Further exploration needs to match students' technological and data analysis proficiencies when determining readiness for student-centered learning that expects students to be calculator proficient and comfortable with basic quantitative procedures such as finding measures of central tendency and variation.

## ACKNOWLEDGEMENTS

There are so many people I want to thank for the support and encouragement they gave me during my coursework and the writing of my dissertation. Each professor was dedicated to helping me learn the material and to encouraging me on my journey. As a member of the first cohort of doctoral students at Montclair State University, everything was new (to both the students and professors). We worked as a team to prepare for the work ahead. Without this support of both my professors and my fellow students, this degree would not have been possible. Thanks to all for your support.

To my dissertation chair, Dr. Kenneth Wolff, I extend special thanks. His unending enthusiasm and attention kept me motivated. He was always accessible and willing to help his students with their research. Without his keen insight and valuable advice, this study would not have taken shape. He was patient when I was exasperated, encouraging when I was discouraged, wise when I was foolishly ready to call it quits [or when I was confounded.]. He was with me every step of the way, and his constant support kept me going. Words alone cannot express the gratitude I hold for this man who helped me develop both academically and personally as I wrote this paper.

I am also particularly indebted to Dr. Andrew McDougall for all his supervision during the formation of this study. His recommendations and suggestions have been invaluable. Without his insights, the task of formulating both the attitudinal questions and the research questions would have been daunting! The direction and clarity with which he interpreted the statistics he compiled as he helped interpret the numbers and helped

highlight the significance of the results in this study, made the numbers become real. He set an example of a world class statistician and made the quantitative part of this dissertation possible.

I would also like to thank committee members Dr. Helen Roberts and Dr. Mark Weinstein for their constructive comments during the formative stages of this study. Their guidance and support during this phase of my dissertation was invaluable. Their combined perspectives helped me to improve the design of the study. They also gave valuable input during the final stages of the writing of this dissertation.

Special thanks go to the teachers and students who were willing to be participants in my study. I learned a lot from doing this research, which could not have happened without your help. Your feedback on the project and on using the calculators taught me what worked and what did not work. Those of you using the TI-Nspire handheld did not know as much about the handheld as I anticipated you would at the start of the project, thereby making your job much harder. You never complained, and you did a wonderful job completing the instructional unit. Thank you so much. Thanks to my students also, for your encouragement and understanding when I had to reschedule meetings with you to meet with my professors.

To my fellow faculty members, thank you for helping me whenever I needed help or encouragement. Special thanks Judy Manzo, Richard Livingston and Raed Dandan for teaching the unit of instruction. Without you, this dissertation would not have happened. John Moraino, my Math supervisor, has been so supportive and understanding throughout the implementation of this dissertation. Larry Hurtado, thanks for your help translating

permission slips into Spanish and for saving my sanity with your Microsoft expertise.

Thanks to Marlene Mora for your assistance in interpreting permission slips into Spanish.

A special thanks to Andrew Zweig and the folks at Texas Instruments for their support and technical expertise with the TI-Nspire and to Suzanne Shipley for reading and commenting on my dissertation.

Finally, I wish to thank my family. Al, you always encouraged me to finish and often had to sacrifice weekends and vacations. You spent many evenings alone while I was working on my research and writing. Lee, without your editorial help, I never would have completed my portfolio, much less my dissertation. Your writing expertise taught me so much. Our weekend editing sessions were fun, rewarding and productive. My children and their spouses never gave up hope. When I was tempted to quit, you kept me going. Mom, I treasure your faith in me and know that your prayers were answered.



### Dedication

Without the encouragement, prayers, love and support of my husband Al, my mother, Leonor, my children, Christopher, Michael, Kevin, Susan Joy, and their spouses, this thesis would still be merely a dream. I thank you all for believing in me and for never doubting that one day this vision would have substance.

I dedicate this dissertation to my grandchildren, Alex, Andrew, Katie and Jacob and to all the grandchildren who yet might come. Know that I believe in you. Believe in yourselves and follow your path. Have faith you can leave this world a little better than you found it.

## **Table of Contents**

List of Tables	xviii
List of Figures	xxiii
CHAPTER 1: THE PROBLEM AND ITS BACKGROUND	1
Introduction	1
Statement of the Problem/Inquiry	3
Research Questions	6
Definition of Terms	6
Adult Skills	6
Authentic Assessments	6
Authentic Content	7
Cognitive Tools	7
Cooperative Learning	7
Data Analysis Cluster of the HSPA	8
Explicit Educational Goals	8
Project-based Learning	8
Problem-based Learning	9
Problem/Project-based Learning	9
Reflection	9
Teacher Facilitation	9
TI-Nspire Handheld	10

Justification of Proposed Research	10
Significance of the Study	12
CHAPTER 2: RELEVANT PRIOR KNOWLEDGE	14
Problem and Project-based Learning	14
Technology	21
How Students Learn	28
Learning Differences	33
Equity Issues	38
CHAPTER 3: PROCEDURES AND METHODS OF RESEARCH/INQUIRY	40
Study Design	40
Data Analysis	41
Participants and Setting	41
Instruments	42
The Instructional Curriculum	43
Intervention Curriculum	43
Traditional Curriculum	44
Variables in the Study	45
Independent Variables	45
Dependent variables	46
Procedure	46
Ethical Issues	48

Trustworthiness	48
Credibility	48
Transferability	49
Dependability	49
Confirmability	50
Limitations of the Study	50
CHAPTER 4: ATTITUDINAL CHANGES	52
Qualitative Research Results	52
Teacher Interviews	53
Student Interviews	57
Control group	57
TI-84 intervention group	60
TI-Nspire traditional group	61
TI-Nspire intervention group	63
Summary of Interviews	66
Quantitative Results for the Attitudinal Survey	69
Category1-Open-ended Statements (Statements 1 – 9)	73
Category 2 – Percents (Statement 10)	77
Category 3 – Interpreting Statistics (Statements 11, 12, 15, 16, 29, 30, 32)	78
Category 4- Creating Graphs(Statements 13, 17 – 19, 24 – 28, 31)	81
Category 5 – Basic Statistics( Statements 20 – 23)	89
Category 6 – Interpreting Graphs (Statements 30 – 34)	91

Summary of Quantitative Findings for the Attitudinal Survey	95
Calculator - TI-84 (E2 + C) and TI-Nspire (E1 + E3)	96
Curriculum-Intervention Curriculum (E1 + E2) and Traditional Intervention Curriculum (E3 + C)	99
Groups-Experimental (E1 + E2 + E3) and Control (C)	100
Grp3( E2 + E3 + C) and Intervention + TI-Nspire (E1)	101
Answer to the Research Question: “Did using problem/project-based learning have an effect on students’ attitudes towards mathematics and data analysis?”	102
CHAPTER 5: QUANTITATIVE RESULTS	104
Study Design and Variables	104
Pre-test and Post-test Results	105
Method of Analysis	105
Summary Statistics	108
Is there a difference in the four study groups?	108
GLM Procedure	108
Interaction Effect	112
Repeated Measures Procedure	113
Repeated Measures Analysis of INSTR*CALC	115
Between Subjects Analysis	115
Within Subjects Analysis	115
Conclusion	117

Did the calculator used have an effect on student scores?	117
Repeated Measures Procedure	117
Between Subjects Analysis	118
Within Subjects Analysis	119
Conclusion	121
Did the instructional unit have an effect on student scores?	121
Repeated Measures Procedure	121
Between Subjects Analysis	121
Within Subjects Analysis	122
Conclusion	123
Was there a difference between the Control group and the rest of the groups combined?	124
Repeated Measures Procedure	124
Between Subjects Analysis	125
Within Subjects Analysis	125
Conclusion	126
Was there a difference between the Inv TI-N group (E1) and Grp3 (E2 + E3 + C))?	128
Repeated Measures Procedure	128
Between Subjects Analysis	128
Within Subjects Analysis	130
Conclusion	131

Summary of Study Group Comparisons	131
What is the effect of a problem/project-based instructional unit on ninth grade basic skills mathematics students' understanding of how to represent, interpret and analyze real world data as measured by their Performance on questions similar those in the Data Analysis Cluster of the NJ HSPA?	133
What is the effect of using the document features of the TI-Nspire in a data analysis unit on the students' mastery of related tools and concepts?	133
What is the effect of the combination of the document features of the TI-Nspire handheld and the problem/project-based unit of instruction on the students' mastery of related tools and concepts?	133
CHAPTER 6: SUMMARY, CONCLUSIONS AND RECOMMENDATION	136
Summary	136
Purpose of the Study	136
Research Design	136
Summary of Attitudinal Findings	138
Summary of Quantitative Findings	143
Method of Analysis	144
Effect of Calculator	145
Effect of Instructional Method	145
Effect of the Interaction of Instruction and Calculator	146
Conclusions	147

Summary	149
Recommendations	151
Implications for Teaching	151
Implications for Future Research	153
Bibliography	155
Appendix A Pre-test	164
Pre-test	165
Appendix B Post-test	173
Post-test	174
Appendix C Attitudinal Survey	183
Attitudinal Survey	184
Appendix D Semi Structured Interview Protocols	189
Student Interview Protocol	190
Teacher Interview Protocol	193
Appendix E Calculator Descriptions	195
TI-Nspire	196
TI-84	201
Appendix F Transcript of Intervention Unit of Instruction	203
Transcript for Intervention Unit of Instruction for the TI-Nspire	204
Answers to Population Problems	237
Answers to Wage Problems	239
Rubric for Problem 4	244



Rubric for Problem 5	247
Unit of Instruction for the TI-84	249
Appendix G Permission to Use Material	279
Peoples Education	280
New Jersey Department of Education	281
Amsco	283

## LIST OF TABLES

<i>Table</i>	<i>Page</i>
Table 4.1 Categories of Attitudinal Statements with Statements in each Category	69
Table 4.2 Structure of the Instructional Groupings	71
Table 4.3 The Eight Cohorts in the Study	71
Table 4.4 Codes used in the Tables and Figures for Chapter 4 - 6	72
Table 4.5 Difference in Mean scores (Post-test – Pre-test) in the Total Quantified Scores for the Attitudinal Survey	73
Table 4.6 Results of Statistical Analysis of the Change in Responses to Statements in Category 1: Open-ended Statements	74
Table 4.7 Results of Statistical Analysis of the Change in Responses to Statement 6, “Teachers explain Open-ended questions very well.”	75
Table 4.8 Results of Statistical Analysis of the Change in Responses to Statement 4, “I can read but do not understand Open-ended questions.”	76
Table 4.9 Results of Statistical Analysis of the Change in Responses to Statement 7, “I usually understand the text or story in Open-ended questions.”	77
Table 4.10 Results of Statistical Analysis of the Change in Responses to Statement 10, “I am good at working with percents.”	77
Table 4.11 Results of Statistical Analysis of the Change in Responses Statements Related to Analyzing Data and Drawing Conclusions from Data	79
Table 4.12 Results of Statistical Analysis of the Change in Responses to Statement 12, “I am good at interpreting tables.”	79

Table 4.13 Results of Statistical Analysis of the Change in Responses to	
Statement 29, “I am good at deciding if a sample is biased or unbiased.”	80
Table 4.14 Results of Statistical Analysis of the Change in Responses to	
Statement 32, “I am good at evaluating arguments based on an analysis of data	81
Table 4.15 Results of Statistical Analysis of the Change in Responses to Statements	
about Drawing Graphs and Modeling Situations	82
Table 4.16 Results of Statistical Analysis of the Change in Responses to	
Statement 19, “ I am good at finding outliers.”	83
Table 4.17 Results of Statistical Analysis of the Change in Responses to	
Statement 24, “I am good at drawing histograms.”	84
Table 4.18 Results of Statistical Analysis of the Change in Responses to	
Statement 18, “I am good at making scatter plots.”	85
Table 4.19 Results of Statistical Analysis of the Change in Responses to	
Statement 25, “I am good at drawing scatter plots.”	85
Table 4.20 Results of Statistical Analysis of the Change in Responses to	
Statement 26, “I am good at drawing bar graphs.”	86
Table 4.21 Results of Statistical Analysis of the Change in Responses to the	
Statement 27, “I am good at drawing circle graphs.”	87
Table 4.22 Results of Statistical Analysis of the Change in Responses to	
Statement 31, “I am good at selecting an appropriate measure of central	
tendency to best describe data.”	88
Table 4.23 Results of Statistical Analysis of the Change in Responses to Statements	

about Basic Statistical Concepts	89
Table 4.24 Results of Statistical Analysis of the Change in Responses to Statement 20, “I am good at finding the mean of a set of data.”	90
Table 4.25 Results of Statistical Analysis of the Change in Responses to Statement 22, “I am good at finding the mode of a set of data.”	90
Table 4.26 Results of Statistical Analysis of the Change in Responses to Statement 21, “I am good at finding the median of a set of data.”	91
Table 4.27 Results of Statistical Analysis of the Change in Responses to Statements about Interpreting and Predicting from Graphs	92
Table 4.28 Results of Statistical Analysis of the Change in Responses to Statement 34, “I am good at interpreting histograms.”	93
Table 4.29 Results of Statistical Analysis of the Change in Responses to Statement 35 “I am good at interpreting scatter plots.”	94
Table 4.30 Results of Statistical Analysis of the Change in Responses to Statement 39, “I am good at drawing a line of best fit.”	94
Table 4.31 Results of Statistical Analysis on the Change in Responses to Statement 40, “I am good at predicting from a line of best fit.”	95
Table 4.32 Codes for Changes in Study Group Responses on the Attitudinal Survey	96
Table 4.33 Summary of Results of Statistical Analysis of the Change in Responses on the Attitudinal Survey (Total and Category Changes)	97
Table 4. 34 Summary of Results of Statistical Analysis of the Change in Responses on Individual Questions on the Attitudinal Survey (Significant and Weak, Non-	

significant Responses)	98
Table 5.1 Pre-test and Post-test Instruments	105
Table 5.2 Means of the Multiple-choice Questions and Open-ended Questions for all Groups and Cohorts	109
Table 5.3 Means of the Total Scores for all Groups and Cohorts	110
Table 5.4 Pre-test and Post-test GLM Procedure Results for the Interaction of Instruction and Calculator	111
Table 5.5 Repeated Measures Analysis of Variance Tests of Hypotheses for Between Subjects Effects for the Interaction of Instruction and Calculator	114
Table 5.6 Repeated Measures Analysis of Variance Univariate Tests of Hypotheses for Within Subjects Effects for the Interaction of Instruction and Calculator	116
Table 5.7 Calculator Means	118
Table 5.8 Repeated Measures Analysis of Variance Tests of Hypotheses for Between Subjects Effects for Calculator	119
Table 5.9 Repeated Measures Analysis of Variance Univariate Tests of Hypotheses for Within Subjects Effects for Calculator	120
Table 5.10 Curriculum Means	122
Table 5.11 Repeated Measures Analysis of Variance Univariate Tests of Hypotheses for Within Subjects Effects for Instructional study Groups	123
Table 5.12 Group Means	124
Table 5.13 Repeated Measures Analysis of Variance Tests of Hypotheses for	

Between Subjects Effects for GROUP	126
Table 5.14 Repeated Measures Analysis of Variance Univariate Tests of Hypotheses for Within Subjects Effects for GROUP	127
Table 5.15 Grp3 Means	128
Table 5.16 Repeated Measures Analysis of Variance Tests of Hypotheses for Between Subjects Effects for Grp3	129
Table 5.17 Repeated Measures Analysis of Variance Univariate Tests of Hypotheses for Within Subjects Effects for Grp3	130

## LIST OF FIGURES

<i>Figure</i>	<i>Page</i>
Figure 3.1 Experimental and Control groups	46
Figure 5.1 Structure of Study Groups	104
Figure 5.2 Graphs for the change in mean scores from Pre-test to Post-test for the four independent study groups	110
Figure 5. 3 Pre-test Interaction Plots for INSTR*CALC	111
Figure 5.4 Graphs for the change in mean scores from Pre-test to Post-test by type of Calculator	118
Figure 5.5 Graphs for the change in mean scores from Pre-test to Post-test for instructional study groups	122
Figure 5.6 Graphs for GROUP and Control change in mean scores from Pre-test to Post-test	125
Figure 5.7 Graphs for Grp3 and InvTI-N change in mean scores from Pre-test to Post-test	129
Figure 6.1 Change in Means, Pre-test to Post-test for the Four Basic Study Groups	148

## CHAPTER 1: THE PROBLEM AND ITS BACKGROUND

### Introduction

We live in a time of extraordinary and accelerating change. New knowledge, tools, and ways of doing and communicating mathematics continue to emerge and evolve....The need to understand and be able to use mathematics in everyday life and in the workplace has never been greater and will continue to increase.

(Leinwand & Burrill, 2001, p. 5 citing Principles and Standards for School Mathematics [NCTM], p. 4)

One area in which students will need to be proficient is analyzing data they encounter in daily life. This study compares problem/project-based learning with a traditional curriculum of unconnected problems dealing with data analysis. In *How People Learn: Brain, Mind, Experience, and School: Expanded Edition* the authors state that students will develop “flexible understanding of when, where, why, and how to use their knowledge to solve new problems if they learn how to extract underlying themes and principles from their learning exercises” (Bransford, Brown & Cocking, 2000, p. 236). The problem/project-based method of instruction is designed to guide students through an initial learning process and then give them time to apply that knowledge to an authentic problem situation using the same concepts. At first glance, this may appear to be similar to traditional approach in which problems are usually well defined and require only a few minutes to solve. However, in a problem/project-based learning environment students must make decisions about what to investigate, what data or information is important, how to organize the data, what mathematical tools are applicable and how to



best present the solution. This in depth study of material “make(s) it possible for the majority of individuals to develop a deep understanding of important subject matter” (Bransford, Brown & Cocking, 2000, p. 6). “A good science or mathematics teacher encourages students to try new possibilities, to venture possible explanations, and to follow them to their logical conclusions” (Leinwald & Burrill, 2001, p. 21).

This study examines the effectiveness of a problem/project-based unit of instruction on the material covered in the NJ HSPA (the New Jersey High School Proficiency Assessment) Data Analysis cluster using the TI-Nspire handheld, document based calculator (see Appendix E for description of TI-Nspire). Data analysis was selected because students often have difficulty working with data. Students must be able to decide what type of graph is best for the given data, be able to construct a graph, and be able to interpret the graph. Interpretation “requires rearranging material concerning the important from the less important factors. To interpret graphs, one can look for relationships among specifiers in a graph or between a specifier and a labeled axis. ... In working with graphs, one could extrapolate or interpolate by noting trends perceived in data or by specifying implications” (Friel, Curcio & Bright, 2001, p. 129). Once the students decide the type of graph to be used and know how to graph the data by hand, using technology can help students become more proficient at interpreting the data.

Using technology, such as the TI-Nspire, “can support investigation by students in every area of mathematics... When technological tools are available, students can focus on decision making, reflection, reasoning, and problem solving (NCTM, 2000, p. 24). The authors of the *Principles and Standards for School Mathematics* consider technology

and modeling to be important tools in problem solving, and recommend that students have the opportunity to use technology to enrich “the range and quality of investigations by providing a means of viewing mathematical ideas from multiple perspectives. Students’ learning is assisted by feedback, which technology can supply” (NCTM, 2000, p. 25). NCTM also states that students should model situations individually and then compare the models with each other. Problem/project-based learning activities provide students with such modeling experiences. “They [students] should learn to ask questions that will help them evaluate the quality of surveys, observational studies, and controlled experiments” (NCTM, 2000, p. 325). This study evaluates the effectiveness of using the TI-Nspire and its document features in support of a four-week problem/project-based unit of instruction. Students gain experience with the modeling process while using the organizational and computational features of the TI-Nspire.

#### Statement of the Problem/Inquiry

In the 2007-2008 school year 60% of the students entering the study site (an urban, northern New Jersey technical high school) were only partially proficient on the GEPA test (the New Jersey eighth grade proficiency test). They are not alone. According to statistics from the NJ Department of Education, in New Jersey’s Abbott Districts (usually urban and/or special needs districts needing improvement) between 53 and 88 percent of students are partially proficient according to their GEPA results (Noehrenberg, 2004). According to the National Assessment of Educational Progress (NAEP), using the NAEP data as the indicator, across all districts, only 7 percent of African American and 32 percent of Hispanic 8th graders scored at or above the proficiency level (Powell &

Anderson, 2007, p. 70).

Research about how people learn, the differences between how novices and experts approach a problem, and use of technology to support learning motivated the approach taken in this study.

Key to expertise is the mastery of concepts that allow for deep understanding of that information, transforming it from a set of facts into usable knowledge. The conceptual framework allows experts to organize information into meaningful patterns and store it hierarchically in [their] memory to facilitate retrieval for problem solving. And unlike pure acquisition of factual knowledge, the mastery of concepts facilitates transfer of learning to new problems. (Donovan, Bransford, & Pellegrino, 2000, p. 2)

My study focuses on strategies that assist students in improving problem solving skills.

Strategies can be taught that allow students to monitor their understanding and progress in problem solving. Research on the performance of experts reveals that they monitor their understanding carefully, making note of when additional information is required, whether new information is consistent with what is already known, and what analogies can be drawn that would advance their understanding. In problem solving, they consider alternatives and are mindful of whether the one chosen is leading to the desired end (Donovan, et al., 2000, p. 2).

To assist students in the problem/project unit of instruction, the students use graphing calculators.

Research has shown that graphing calculators can enhance learning and

computers can provide useful practice. We need to compile evidence of what actually happens when they [graphing calculators] are used, including what students learn with calculators that they do not learn without them and what they fail to learn when they use calculators that they do not learn without their use.

(Katz, 2007, p. 2)

My study also examines whether teaching a problem/project-based data analysis unit using the document and statistical features of the TI-Nspire helps students master the material required by the state for the HSPA. That is, does using a problem/project-based instructional model in combination with the TI-Nspire, enable students to gain a deeper understanding of the mathematical concepts involved. In addition, the study investigates whether using the document features of the handheld helps students stay organized and enables them to easily refer to previous parts of the project.

This study adds to the knowledge base of our understanding of the role that problem/project-based learning, supported by hand-held technology, has on high school students' mastery of data analysis concepts, their understanding of mathematical modeling and their attitude toward mathematics and data analysis.

NCTM "advocates a move away from memorization to an emphasis on deeper thinking (e.g. applications and problem solving). One way to approach these goals is to use problem/based learning, which is designed to involve students in investigations of 'authentic problems'" (Meyer, Turner & Spencer, 1997, p. 501). "When projects are cognitively complex, they have the potential to help students learn because they must represent knowledge in a variety of ways, pose and solve real problems, and use

knowledge to create artifacts” (Meyer, et al., 1997, p. 505).

### Research Questions

1. What is the effect of a problem/project-based instructional unit on ninth grade basic skills mathematics students’ understanding of how to represent, interpret and analyze real world data as measured by their performance on questions similar those in the Data Analysis Cluster of the NJ HSPA?
2. What is the effect of using the document features of the TI-Nspire in a data analysis unit on the students’ mastery of related tools and concepts?
3. What is the effect of the combination of the document features of the TI-Nspire handheld and the problem/project-based unit of instruction on the students’ mastery of related tools and concepts?
4. What is the effect of using problem/project-based learning on students’ attitude towards mathematics and data analysis?

### Definition of Terms

#### *Adult Skills*

Adult skills refer to the skills that students will probably need when they enter the work world. These include working in a team environment, solving a relevant problem and communicating ideas to the group and others (Diehl, et al., 1999)

#### *Authentic Assessment*

Authentic assessments are engaging real world problems or questions of importance, in which students must use content knowledge to fashion creative and effective responses. The tasks should be similar to the kinds of problems faced by adult

citizens and consumers or professionals in the field (Sullivan, 2000; Wiggins, 1993). Students must demonstrate mastery of the important concepts when presenting their solutions. The task presented is usually graded according to a rubric with which the students are familiar.

### *Authentic Content*

Authentic content refers to using material that fosters students' learning of important content while helping them realize that the content can be transferred to other contexts. It should be "material that goes to the heart of the discipline and material that allows for personal application of ideas that go beyond school-related activities" (Valencia & Peters, 1991, p. 590).

### *Cognitive Tools*

Cognitive tools refer to learning with the help of technology. The technology is used to assist in the thinking process, not do the thinking for the student. The student decides how and when to use the technology to help them construct their knowledge (Rusbult, 2008).

### *Cooperative Learning*

Cooperative learning is not just group work. Every member of the group is responsible for making sure that everyone in the group learns the desired concepts. Students gain from each other's expertise. They share a common grade. Everyone in the group is responsible for part of the final project presentation (Kagan 1994; Thousand, Nevins et al. 1994).

### *Data Analysis Cluster of the HSPA*

The data analysis cluster of the HSPA is based on the New Jersey Core Content Standards for Mathematics (2002). The data analysis cluster includes data analysis, probability, statistics and discrete mathematics. The intervention unit for this study is limited to statistics and data analysis.

### *Explicit Educational Goals*

Explicit educational goals refers to “provid[ing] students with opportunities for educationally useful experiences, and help[ing] students learn more from their experiences” (Rusbult, 2008, p. 1). Activities should be designed with goals defined in terms of the concepts and skills to be learned and should provide real world experiences with these concepts, helping students learn from their experiences (Rusbult, 2008).

### *Project-based Learning*

“Project-based learning (PBL) is a teaching and learning strategy that involves students in complex activities, and enables them to engage in exploring important and meaningful questions through a continuous process of investigation and collaboration” (Shriki & Lavy, 2005, p. 185). According to the definitions found in PBL handbooks for teachers, projects are complex tasks, based on challenging questions or problems that involve students in design, problem solving, decision-making, or investigative activities. They give students the opportunity to work relatively autonomously over extended periods of time and culminate in realistic products or presentations (Jones, Rasmussen & Moffitt, 1997; Thomas, Mergendoller & Michaelson, 1999). Other defining features (which are defined below) found in the literature include authentic content, authentic

assessment, teacher facilitation but not direction, explicit educational goals, (Moursund, 1999), cooperative learning, reflection, and incorporation of adult skills (Diehl, Grobe, Lopez & Cabral, 1999). Project-based instruction includes features related to the use of an authentic (“driving”) question, a community of inquiry, and the use of cognitive (technology-based) tools (Blumenfeld, Soloway, Marx, Krajcik, Guzdial & Palincsar, 1991; Krajcik, Blumenfeld, Marx, Bass, Fredricks & Soloway, 1994; Marx, Blumenfeld, Krajcik & Soloway, 1994).

### *Problem-based Learning*

Problem-based learning uses a real world simulated problem instead of, or in combination with, a project. Often problem-based learning is used as an introduction to a project. This gives the students some direction when designing their project.

### *Problem/project-based Learning*

Problem/project-based learning combines problem-based learning and project-based learning. Units of instruction will start out with problems that are solved as a group. These problems lead into the project-based unit done by the students.

### *Reflection*

Reflection should be both individual and group. Each member should reflect on what he/she has mastered and what still needs to be accomplished. The group should ask themselves what they have accomplished and how it is contributing to the final desired results (Rusbult, 1998).

### *Teacher Facilitation*

Teacher facilitation refers to teachers allowing “students to take an active role in



guiding their own learning and in teaching one another” (Neville, 1999, p. 393). The teacher “must allow students to learn through the study of various resources. Rather than telling students what they should learn and in what sequence they should learn, the tutor must help students determine this for themselves” (Neville, 1999, p. 393).

### *TI-Nspire Handheld*

The TI-Nspire is a handheld calculator with document features similar to a computer. It allows students to keep all of their work in one place and to save their work from day to day, allowing students to refer back to work done previously. The TI-Nspire can also be used as a TI-84 calculator by changing the front face on the calculator. For the study, the students using the TI-Nspire all use the TI-Nspire face rather than the TI-84 face.

### Justification of Proposed Research

New Jersey’s urban students traditionally do not do well on the NJ HSPA exam. Most of the current curricula for ‘Basic Skills I’ courses give students a plethora of problems like the ones traditionally found on the state test. Some of the students walk away from the test saying that we reviewed everything that was on the test while others say we did not review anything that was on the test. We need to find a way to teach the students the concepts, not the problems. We need to find ways to engage the students in the learning experience.

Researchers, such as Donovan, et al., (2000), Katz, (2007), and the 2008 National Mathematics Advisory Panel (NMAP) panel, state that research needs to be done on how the use of calculators affects students’ conceptual understanding and their ability to solve

real world problems, and on the potential for new technologies to provide opportunities to incorporate formative assessment into teaching in an efficient and user-friendly fashion.

As discussed in the literature review (Chapter 2), there is some disagreement as to whether problem/project-type learning helps students transfer knowledge to new situations. This dissertation's research adds to the body of knowledge that addresses transferring knowledge from one situation to another.

Most of the literature I found on project-based learning focused on grades K-8. There was not much research at the high school level, especially in mathematics. Since 1998, *The Journal of Research in Mathematics Education* (JRME) has published three research articles that addressed project-based learning at the high school level. *Open and Closed Mathematics: Student Experiences and Understandings* by Jo Boaler (1998) discusses Open-ended activities versus traditional curriculum. *Teaching and Learning Mathematics for Social Justice in an Urban, Latino School* by Eric Gutstein (2003) relates research on using standards based real world projects to help reach students. *Slower Algebra Students Meet Faster Tools: Solving Algebra Word Problems with Graphing Software* by Michal Yerushalmy (2006) discusses teaching less successful students with software that has the capabilities of a graphing calculator in real world problems over a three year course of study. NCTM has published a number of articles, including *High School Students' Intuitive Understandings of Geometric Transformations* by Karen F. Hollebrands (2003) which discusses analyzing student work on transformations in Geometry. The article discusses different approaches students used. *A Problem Approach to Mathematics Instruction* by Dianne Erickson (1999) discusses the

logistics of trying to implement problem-based learning in the mathematics classroom.

Between 1997 and 2008, Education Research Complete had nineteen references to project-based learning in mathematics classes. Of those, eight involved college level students, five addressed grades K-8 and three were at the high school level. One of the articles discussed a template for design-based lessons, two referred to a study on blood circulation and two discussed quadratic equations in the real world. The report *Adding it Up: Helping Children Learn Mathematics* (Kilpatrick, Swafford & Findell, 2001) addresses grades K-8 and recommends that students should focus on problem solving. The report does not discuss high school project-based learning.

#### Significance of the Study

As mentioned earlier, most students entering the study site, as in most NJ Abbott Schools, are not yet proficient in the skills needed to pass the HSPA. If we can find methods to better reach our students, hopefully we can close the achievement gap between urban students and schools with a much higher percentage of students who consistently test at or above the proficiency level. If this study shows significant results with the student population, hopefully other schools with similar student populations will be able to use this approach to help their students.

The document feature of the TI-Nspire handheld is new (it was released for sale in September 2007) so there is little research on how this feature will support student learning of mathematics. It is expected that by using the TI-Nspire, students will spend more time on task. In addition, it is anticipated that having all of a student's work in one place will help students stay organized and allow them to easily refer to their previous

work.

Working on a problem/project-based unit is expected to enhance student understanding of the data analysis concepts covered in the unit. It is also expected that students will be able to transfer the knowledge learned in the problem/project-based data analysis unit to problems in other settings. The use of multiple representations should enhance the learning for students with different learning styles.

## CHAPTER 2: RELEVANT PRIOR KNOWLEDGE

This chapter includes a review of research on problem and project-based learning, technology, how students learn and equity. The problem and project-based section includes a discussion of some research on mathematical modeling, an integral part of project-based learning. The technology section focuses on the use of handheld calculators and their place in the high school mathematics classroom. The how students learn section discusses the different learning styles our student use and the equity section talks about setting high, but achievable standards for all students. Problem and project-based learning provide many opportunities for students to show off their individual and group talents. Working in groups can help both the slower and more advanced students in their pursuit of mathematical excellence.

### Problem and Project-based Learning

Students must be given opportunities to construct their own knowledge through interactions with the social and physical environment (Novick, 1996). One way to do this is to incorporate projects into the learning environment. According to the Southern Regional Educational Board (SREB) and Jobs for the Future, project-based learning complements and connects two important trends in education:

1. The use of external standards to guide changes in curriculum, instruction and organization:
2. The creation of community-based and school-based opportunities for students to immerse themselves in the adult world of working and learning (SREB, 2000, p. 3).

If students are viewed as “intrinsically motivated, and self-directed” (Novick, 1996, p. 3) they can be expected to make sense of their experiences (Meyer, Turner & Spencer, 1997). The goal is to immerse students in quality projects that incorporate the six traits of authenticity, academic rigor, applied learning, active exploration, adult relationships and assessment (Steinberg, 1998).

As noted in the SREB report, projects

Diverge from the typical school fare of absorbing and regurgitating bits of knowledge. Worksheets, chapter reviews, oral recitations and tests can reinforce students’ skills and knowledge. However, students can become passive and cynical if they are confronted with these teaching strategies hour after hour, day after day (SREB, 2000, p. 4).

As Henry Pollak (2007) points out, we give students all sorts of reasons why they need to know the mathematics currently being studied. Most of those reasons, such as, “Right now you need it because of the test. This test is going to allow you to get into a good college, and that college then will allow you to get the good job and become an intelligent citizen and get ahead” (Pollak, 2007, p. 112) lead to delayed gratification. He does not “think you can motivate very many students by the beauty of mathematics alone without seeing the usefulness” (Pollak, 2007, p. 112).

Mathematics should not be thought of as a set of skills, but rather as “the science for searching for order and patterns in the world around us” (Novick, 96, p. 3). The SREB also found that “too few students are gaining a deep understanding of what they are learning” (SREB, 2000, p. 3). Projects help students see the whole, rather than just the

parts, thereby gaining the concepts often missed in piecemeal learning. “Expertise consists not only of knowing concepts, information and procedures, but also of being able to apply them to problems” (SREB, p. 6). They also help make learning dynamic; helping students make sense of the information they are learning and helping them learn to apply this knowledge to other situations.

When the National Science Foundation decided to invest millions of dollars in developing new mathematics textbooks which would align with the *Curriculum and Evaluation Standards for School Mathematics*, by NCTM, they created curriculum development teams consisting of mathematics educators, mathematicians and classroom teachers [who] worked together to produce mathematics textbooks that embodied standards-based characteristics, including active engagement of students, a focus on problem-solving, and attention to connections within mathematical strands as well as to real-life contexts” (Tarr, Reys, R., Reys, B., Chávez, Shih & Osterlind 2008, p. 248). This is consistent with the concept of problem and project-based learning. “Project-based learning aims to engage them [students] in realistic, thought-provoking problems” (David, 2008, p. 80). Students traditionally work in groups to solve a problem and in the process create some kind of project (David, 2008; Harada, Kirio, & Yamamoto, 2008). These projects encourage interaction among students. Too often, “learning in school can be primarily an individual mental activity that requires little or no engagement with tools or materials. Learning outside of school often involves other people as well as available tools and materials” (SREB, 2000, p. 6). Bringing this collaboration into the classroom should increase student understanding. Research has “found that students’ scores on

standardized tests and alternative assessments were higher if their classes involved work that resembled real situations” (SREB, 2000, p. 6).

Claude Janvier discusses applying mathematics learned in school to mathematics needed on the job. He found that employees could often solve problems on the job that they do not recognize out of context on written tests. “Efficient problem solvers rely on the context of the problem and the fundamental relationships implicit in the problem to drive their reasoning rather than on transforming the relationship to equations and manipulating equations (Janvier, 1990, p. 187).

Projects need to have a driving question that must be formulated with care to ensure that students have to learn the concepts desired for the unit in order to answer the question. This driving question should be based on a ‘real world’ situation or problem and must be “crafted to make connections between activities and the underlying conceptual knowledge that one might hope to foster” (Barron, Schwartz, Vye, Moore, Petrosino, Zech & Bransford, 1998, p. 274). As students become involved in the project, they rely on their own strengths, and the strengths of the others in the group, to decide on what approach they take during their investigation. “Project-based learning creates opportunities for groups of students to investigate meaningful questions that require them to gather information and think critically” (David, 2008, p. 80). Projects provide opportunities where “discussion and collaboration are valued in building a climate of intellectual challenge. Rather than rely on the teacher as an unquestioned authority, students in these situations are expected to propose and defend mathematical ideas and conjectures and to respond thoughtfully to the mathematical arguments of their peers....



Students learn to speak and act mathematically by anticipating and mathematical discussion in solving new or unfamiliar problems” (Goos, 2004, p. 259).

One of the problems with project-based learning is that students have a hard time focusing on the important concepts to be learned. Sometimes it helps if the group does a problem together to give students an idea of what is expected of them and to teach the concepts needed to do a project. Problem-based learning “involves the use of authentic but simulated problems that students and teachers can explore collaboratively” (Barron, et al., 1998, p. 277). The problem serves as a scaffold for the more open-ended type of project. The students “develop a level of shared knowledge and skill that prepares them to undertake the actual projects. By following the problem with a project, students are likely to develop more flexible levels of skills and understanding” (Barron, et al., 1998, p. 278). The problems that are done together help the students focus on the important concepts. After completing a group problem, students apply what has been learned to their own project. The group problem helps them focus on the important concepts when they are designing their own projects. “Learning occurs when assistance is provided at opportune points and learner zone of proximal development.... Movement from the inter-psychological to the intra-psychological plane characterizes performance as moving from being assisted to being independent overtime” (Hufford-Ackles, Fuson & Sherin, 2004, p. 83). Thus as students formulate their project goals, it is important to make sure that they include the learning of the desired concepts. Having a rubric for evaluating the project can help. Through the shared rubric, the teacher can specify the concepts that need to be demonstrated in the project.

Problem- and project-based learning should build in opportunities for self-assessment and revision. “Self-assessment helps students develop the ability to monitor their own understanding and to find resources to deepen it when necessary” (Barron, et al., 1998, p. 284). Teacher input is also vital. This can take the form of a formal lecture, small group or individual suggestions, or feedback on student project progress reports. Teacher feedback should be general and should alert students to the key concepts that they need to focus on or rethink. Teachers should help with the concepts where needed, but should not tell the students how to apply them to their projects. The students need to decide this for themselves (Barron, et al., 1998). “The teacher becomes a facilitator, diagnostician, promoter, guide to knowledge and initiator” (Ticha & Hospesova, 2006, p. 130).

One of the things that the group, and teacher, must monitor is participation in the group. Some students find the openness of projects disconcerting. They are uncomfortable with the lack of structure and direction in projects and would prefer that the teacher direct the activity (Boaler, 2002). These students may be reluctant to participate. The teacher must assure that every member of the group has to be involved in the project at all times. During the presentation of the project, each member of the group should do part of the presentation.

Working in collaborative peer groups, students have an opportunity to own the ideas they are constructing and to experience themselves and their partners as active participants in creating personal mathematical insights. Nevertheless, it is important to recognize that not all student constructions are equally valid,

although incomplete or unacceptable constructions can form the basis of classroom activities and discussion of different interpretations. Here, the teacher as a more experienced knower of the discipline plays a crucial role in selecting student ideas that are fruitful to pursue (Goos, 2004, p. 263).

This is why it is vital that the teacher play an active role while the students are developing their projects. Projects selected by the students can help increase interest level.

Individual interests are conceived of as dispositions that are based on mental schemata associating the objects of interest with positive emotional experiences and the personal value system. During interest-driven actions, the latent disposition becomes the actualized interest (state). The experience of competence and personal control, the feeling of autonomy and self-determination, and a positive emotional state are all characteristics of this action (Koller, Baumert & Schnabel, 2001, p. 449)

“Situational interest is generated by external stimuli; that is, the ‘interestingness’ of the situation or the object” (Koller et al., 2001, p. 449). The assignment itself is externally generated by the teacher. However, the development of the project is student generated. As the students become involved in their projects, it is hoped that their interest evolves from situational to actualized interest.

As students become more comfortable with project-based learning, they discover areas of personal interest that they would like to explore. The exciting part is the formulation of the problem. Exactly what do we want to know? What do we already

know? Pollak states,

When is the problem formulation over? When have you finished in fact the key stage of problem solving? And the answer is: When you get to the point where the mathematics itself is familiar. So that's a moving target – as we hope – as our students get older and better, they know more and more mathematics, and there is less and less that you have to do in formulating before you get to the point at which it's routine (2007, p. 115).

### Technology

Conceptual understanding must be coupled with basic math and reading skills.

“Students cannot do their job well if they do not understand the stepping stones of basic computation, yet computation is best learned, most meaningful and motivational, and most likely to produce results when learned in the presence of real-life problems in mathematics”(Stumbo & Lusi, 2005, p. 2). Because many students lack these basic skills, too much time is spent working on remediation instead of teaching new concepts. The calculator can help fill in some of the gaps in basic computational knowledge, allowing more time for more advanced concepts, e.g., if students know that a computational procedure (such as summing a set of numbers) must be performed but they are not skilled at that task, the calculator can help fill in the skills gap. To this end students need to be calculator and technology proficient. “Calculators don't solve problems. Calculators find solutions only after people have done the problem solving” (Steen, 1997, p. 92).

Students need to know how and when to use the calculator, not every problem requires a calculator and students must learn to differentiate between calculator and non

calculator problems. The calculator should be a problem solving tool, not an end in itself. Students must be able to think through what must be done to solve a problem before they turn to technology.

“Technology is essential in teaching and learning mathematics. It influences the mathematics that is taught and enhances student learning” (NCTM, 2000, p. 25).

Teaching with technology is “an approach that cultivates habits of mind that attend to the deeper, underlying structure of mathematics and it imbeds this way of thinking longitudinally in students’ school experiences, beginning with the elementary grades”(Katz, 2007, p. 1). The use of technology in the classroom can assist in providing opportunities for students to compare and contrast situations. The multiple representations available to students make comparisons and contrasts between problems and situations relatively easy. For example, students can look at a graph and a table of values or they can solve problems algebraically and can verify them graphically, receiving positive feedback of their understanding.

Because many new technologies are interactive, it is now easier to create environments in which students can learn by doing, receive feedback, and continually refine their understanding and build new knowledge. The new technologies can also help people visualize difficult-to-understand concepts (Bransford, Brown & Cockney, 2000, p. 206).

Because of issues related to cost and space, graphing calculators are a more cost efficient way to allow each student to have his or her own technology. Referring to hand held graphing calculators, Demana and Waits state, “Every classroom, could be turned

into a computer lab, and every student could have his or her own inexpensive personal computer with built-in mathematics software” (Demana and Waits, 2000, p. 53).

Technology makes studying certain areas of mathematics, such as data analysis, more feasible.

There are many concepts related to data analysis and to understanding what a set of data is trying to tell you. Often to get what you want, you have to process more numbers than you have time to do. The pedagogic program is the following: Suppose, you have a thousand numbers and you need to know what the structure of that set looks like. By the time the class can agree on what this is, they have long since forgotten why they were interested in the problem. And so technology has made it possible to teach certain subjects and to get involved in some things that are very interesting and very important -you just couldn't do them without technology (Pollak, 2007, p. 116).

Having technology readily available in the classroom can help achieve equity in the classroom by giving ‘all students’ opportunities to explore complex problems and mathematical ideas” (NCTM, 2000, p.13). Technology can also be effective in attracting students who disengage from non-technological approaches to mathematics. It is important that all students have opportunities to use technology in appropriate ways so that they have access to interesting and important mathematical ideas. Access to technology must not become yet another dimension of educational inequity (NCTM, 2000, p. 14).

“Calculators reduce the drudgery of applying arithmetic and algebraic procedures when those procedures are not the focus of the lesson. They provide better ways to compute and manipulate symbols” (Demana and Waits, 2000, p. 57). The graphing calculator is a tool that permits students to work with multiple representations of the same data.

Multiple representations allow students to experience different ways of thinking, develop better insights and understandings of problem situations, and increase comprehension about mathematical concepts... [The calculator also] empowers students who may have limited mathematical knowledge and limited symbolic and numeric manipulation skills to investigate problem situations (Erbaş, Ledford, Polly & Orill, 2004, p. 300).

When students are given time to experiment with different representations of data, they begin to make conjectures and see relationships between the different representations and begin to understand underlying concepts (Bransford, et al., 2000, p. 58). “When technological tools are available, students can focus on decision making, reflection, reasoning, and problem solving” (NCTM, 2000, p. 25). “Opportunities for student learning are amplified when students can take mathematical meaningful actions on mathematical objects, immediately see mathematically meaningful consequences, and reflect on their meaning” (Dick, Burrill & Brady, 2007, p. 19).

Graphing calculators allow students to use multiple forms of representation of data to help them understand the problem at hand. Not all students will select the same form of representing data for a specific problem, but they can discuss the manner in

which they arrived at a solution using whichever method they choose (Schultz & Waters, 2000). “The ability to operate within and between different representations of the same concept or problem setting is fundamental in effectively applying technology to enhance mathematics learning” (Demana & Waits, 1990, p. 218).

Using graphing calculators can enhance teaching by helping students focus on conceptual understanding and problem solving strategies by decreasing time spent on computation, allowing the focus to be on understanding. Relationships between different representations of the information for a given problem situation are easy to examine using the graphing and table features of the calculators. Students tend to be more engaged in problem solving when working with the technology. They can be asked more in depth questions that will test their understanding of the underlying concepts (SRI International, 2006).

There are many choices for technology, including graphing calculators such as the TI-84 and the new hand held TI-Nspire, which tend to increase student involvement in problem solving situations (SRI, 2007). The TI-Nspire takes the potential for student engagement to a new level by allowing students to keep all their work, including notes, in one document. A report released on the anticipated effect of using the new handheld stated, “One key new capacity is that students work in a ‘document’, an organized presentation of multiple screens of mathematics which can be saved, shared, annotated, and revised” (SRI International, 2006, p. 2). This document feature may help teachers keep track of student progress, give advice and answer questions from each student.

TI-Nspire’s linked representations should help teachers to focus students’



attention on the relationships among multiple representations, such as algebraic equations, geometric constructions, graphs, and tables. ... TI-Nspire's multiple representations and communication capabilities can make thinking visible and can support the classroom teacher to engage students in doing and discussing important mathematics (SRI International, 2006, p.1).

"Constructive feedback early in the learning process can improve student achievement" (SRI, 2006, p. 5). The document feature should also help students stay organized. All of their work is in one place. It can be reviewed, edited, and changed at any time. This allows both the student and the teacher to monitor progress.

Formative assessment should be a continuing process throughout a project. A student can adjust his/her thinking based on the feedback given by the teacher. The teacher can also assess what the class does and does not know, thus refining the instruction to help students refine their understanding (Scardemalia & Bereiter, 1993). Students develop higher order thinking skills when they are provided feedback on their progress and are encouraged to refine and improve their work (Gall, 1984; Dillon & Wittrock, 1984).

According to Donovan, Bransford and Pellegrino (2000) research needs to Explore the potential of new technologies that provide the opportunity to incorporate formative assessment into teaching in efficient and user-friendly fashion. This research effort should consider the relationship between formative and summative assessments. If the goal of learning is to achieve deep understanding, then formative assessment should identify problems and progress

toward that goal, and summative assessment should measure the level of success at reaching that goal. Clearly they are different stages of the same process and should be closely tied in design and purpose (p. 39).

Student use of the TI-Nspire documents should make thinking visible. As students develop their projects, they should increase their organizational and record keeping skills. All of their work is in one place and can be rearranged as needed to develop the flow of their project. As the student draws conclusions and asks questions about data sets, all of this can be recorded in his/her notes. It is easy for the student to look at prior representations because they are all still in one document. Because each student can explicitly label graphs and plots with their words, their graphs are more understandable and easier to recall later. Multiple representations of the problem can be shown on the same screen, allowing students to compare and contrast information, thereby drawing conclusions more easily.

Technology allows students much more flexibility in designing graphs and trying different graphical representations in a shorter amount of time. Although using data makes mathematics easier because it is more concrete to students, data are also challenging in that students need to make predictions and inference (McGehee & Griffith, 2004, p. 344).

Because the document capability of a graphing calculator is a new feature:

There is no direct research relating document features to mathematics learning gains...The capabilities of documents align with long-standing findings in scientific literature on how people learn. This capability can enable teachers to

create a more engaged classroom, with greater motivation and achievement (SRI International, 2006, p. 10).

It is expected that using the TI-Nspire will motivate students to spend more time on task. Having all of a student's work in one place should also increase time on task. Being able to go back and look at prior work should make it easy for students to look at multiple representations of the same data.

Research also needs to be done to show if this in-depth type of learning, using multiple representations, will help students transfer knowledge to new situations. Transfer is also affected by the context of original learning; people can learn in one context, yet fail to transfer to other contexts. Research has indicated that transfer across contexts is especially difficult when a subject is taught only in a single context rather than in multiple contexts. ... One way to deal with lack of flexibility is to ask learners to solve a specific case and then provide them with an additional, similar case; the goal is to help them abstract general principles that lead to more flexible transfer (Bransford, et al., 2000, p. 62).

#### How Students Learn

“Knowledge is an entity that is acquired in one setting and then transported to other settings” (Peressini, Borko, Romagnano, Knuth & Willis, 2004 p. 69). Students come to us with their own knowledge base and preconceived notions (Bransford, et al., 2000; Donovan, et al., 2000). Teachers must “use this knowledge as a starting point for new instruction, and monitor students' changing conceptions as instruction proceeds” (Bransford, et al., 2000, p. 11). We must help students grow intellectually, keeping in

mind that “‘usable knowledge’ is not the same as a mere list of disconnected facts. Experts’ knowledge is connected and organized around important concepts” (Bransford, et al., 2000, p. 9).

Drawing out and working with existing understandings is important for learners of all ages. Numerous research experiments demonstrate the persistence of preexisting understandings among older students even after a new model has been taught that contradicts the naive understanding. For example, in a study of physics students from elite, technologically oriented colleges, Andrea DiSessa (1982) instructed them to play a computerized game that required them to direct a computer-simulated object called a dynaturtle so that it would hit a moving target and do so with minimum speed at impact. Participants were introduced to the game and given a hands-on trial that allowed them to apply a few taps with a small wooden mallet to a tennis ball on a table before beginning the game. Elementary school children also played the same game. DiSessa found that both groups of students failed dismally. Success would have required demonstrating an understanding of Newton's laws of motion. Despite their training, college physics students, like the elementary school children, aimed the moving dynaturtle directly at the target, failing to take momentum into account (Donovan, et al., 2000, p. 11).

As we teach students, it is vital that we help them draw conclusions and apply their knowledge to different situations. This takes time. “Providing students with time to learn [also] includes providing enough time for them to process information...Learning cannot be rushed; the complex cognitive activity of information integration requires time” (Donovan, et al., 2000, p. 58). Learning activities must include, “The ability to plan

a task, to notice patterns, to generate reasonable arguments and explanations, and to draw analogies to other problems are all more closely intertwined with factual knowledge than was once believed” (Bransford, et al., 2000, p. 16).

In order to provide students with sufficient time to learn, we must limit the number of concepts we teach. “Superficial coverage of all topics in a subject area must be replaced with in-depth coverage of fewer topics that allows key concepts in that discipline to be understood” (Bransford, et al., 2000, p. 20). To develop competence in an area of inquiry, students must have opportunities to learn with understanding.

Deep understanding of subject matter transforms factual information into usable knowledge. A pronounced difference between experts and novices is that experts' command of concepts shapes their understanding of new information: it allows them to see patterns, relationships, or discrepancies that are not apparent to novices (Donovan, et al., p. 12).

The process of acquiring knowledge takes time. It is not just a matter of memorizing facts. Experts

Do not necessarily have better overall memories than other people. But their conceptual understanding allows them to extract a level of meaning from information that is not apparent to novices, and this helps them select and remember relevant information. Experts are also able to fluently access relevant knowledge because their understanding of subject matter allows them to quickly identify what is relevant (Donovan, et al., 2000. p. 12).

Students need to be provided with opportunities that will help them acquire

enough knowledge and skills to be able to synthesize material they are exposed to. They need to be able to decide what mathematical concepts are applicable in new problem situations.

One way to help students learn about conditions of applicability is to assign word problems that require students to use appropriate concepts and formulas. If well designed, these problems can help students learn when, where, and why to use the knowledge they are learning (Bransford, et al., 2000, p. 43).

As students become more skilled at problem-solving, their ability to form new knowledge from prior learning is enhanced. The transferability of this

New knowledge can be enhanced through the use of ‘contrasting cases’, a concept from the field of perceptual learning. Appropriately arranged contrasts can help people notice new features that previously escaped their attention and learn which features are relevant or irrelevant to a particular concept. The benefits of appropriately arranged cases apply not only to perceptual learning, but also to conceptual learning (Bransford, et al., 2000, p. 60).

Feedback is vital in helping students achieve the transferability of knowledge. It is important for successful learning, but it should not be regarded as a unidimensional concept. For example, feedback that signals progress in memorizing facts and formulas is different from feedback that signals the state of the students’ understanding (Bransford, et al., 2000, p. 59). Feedback that addresses understanding can help students transfer knowledge.

“Transfer is affected by the degree to which people learn with understanding

rather than merely memorize sets of facts or follow a fixed set of procedures” (Bransford, et al., 2000, p. 55). Memorization of facts is not enough. Students must understand how and when to use these facts. It is this understanding that helps students transfer that knowledge from one situation to another.

Not everyone agrees that students should model situations to enhance their learning. According to Chang, (2008) in a NY Times article *Study suggests Math teachers Scrap Balls and Slices*, some researchers believe that modeling algebra with ‘real world’ problems is not the best way for students to learn. They feel that teachers should focus on the abstract rather than concrete examples. Ohio State researchers did an experiment with college students and concluded that students taught in the abstract were better at transferring to new situations than students who used concrete examples. According to Chang, one of the researchers, Jennifer A. Kaminski said, “The problem with ‘real world’ examples was that they obscured the underlying math, and students were not able to transfer their knowledge to new problems” (Chang, 2008, p. 2). The article said that “other mathematicians called the findings interesting, but warned against over generalizing. ‘One size can’t fit all,’ said Douglas H. Clements, a professor of learning and instruction at the University of Buffalo. ‘That’s not denying what these guys have found, whatsoever.’” (Chang, 2008, p. 3). The National Mathematics Advisory Panel (NMAP) states that

The use of ‘real world’ contexts to introduce mathematical ideas has been advocated, with the term ‘real world’ being used in varied ways. A synthesis of findings from a small number of high-quality studies indicates that if

mathematical ideas are taught using ‘real world’ contexts, then students’ performance on assessments involving similar problems is improved. However, performance on assessments more focused on other aspects of mathematics learning, such as computation, simple word problems, and equation solving, is not improved (NMAP, 2008, p. 23).

It is expected that this research will add some new light on this argument, taking into account more of what NMAP found about effort.

In the 2008 NMAP report it states,

Experimental studies have demonstrated that changing children’s beliefs from a focus on ability to a focus on effort increases their engagement in mathematics learning, which in turn improves mathematics outcomes. [Research shows] that the engagement and sense of efficacy of African-American and Hispanic students in mathematical learning contexts tend to be lower than that of white and Asian students, but also that it can be significantly increased (NMAP, 2008, p. 20).

In an interview with *USA Today*, the chairperson of the panel, D. L. Faulkner stated, “Effort counts. Students who believe that working hard will make them smarter in math actually do achieve better” (Toppo, 2008, p. 6D). The key is how to increase student effort. I expect that the TI-Nspire will increase student engagement and therefore the amount of time and effort is put into learning.

### *Learning Differences*

Research recognizes that while we all have multiple intelligences, as individuals some of our intelligences are more developed than others. Thus teachers must strive to



help every student develop each intelligence to its highest level (Corsini, 1998) and strive towards integrating these intelligences when approaching a problem solving situation. Although each person has a unique combination of abilities, many do not develop their abilities to the fullest. Because these abilities are not fixed and their interactions remain forever dynamic, we have the potential to develop indefinitely (Gardner, 1999). For example, when doing problems requiring spatial intelligence, some students can visualize the objects or moves in their heads, while others must physically handle or move the shapes. The more opportunities students have to physically use shapes, the easier it becomes for them to visualize shapes (Baldwin 1984). In the mathematics classroom, the teacher should use an overall problem solving approach to his/her teaching. By selecting problems that can be solved using a variety of approaches, students are able to use the intelligences with which they are most comfortable. Furthermore sharing these approaches with others helps to develop all students' intelligences. There are many classic problems that lend themselves to many different approaches. Here is a typical one:

Your school has 1000 lockers, all open and 1000 students. The first student enters school and **closes every locker**. Then the second student **opens every other locker** beginning with **number 2**. Next the third student **changes the state of every third** locker beginning with **number 3**. (If the locker is open the student shuts it, and if the locker is closed the student opens it.) The fourth student **changes the state of every fourth** locker beginning with **number 4**. This continues until the thousand students have all followed the pattern with the thousand lockers. At the end, which lockers will be open and which will be closed?

Students will use a variety of approaches to solve this problem, depending on the type of learner they are. Kinesthetic learners will probably use manipulatives to simulate the situation or will physically act out the situation with a smaller number of lockers. The visual-spatial learners will draw diagrams, illustrating who or what goes where. The logical-mathematical learners may try a simpler problem, devising a strategy and then applying it to the more complex situation. Linguistic learners will write about what has to be done. The interpersonal learners will brainstorm possible solutions and then try them out (Armstrong 1994; Corsin 1998; Sternberg 1998). As students share solutions with one another, they begin to gain an appreciation for different approaches to problem solving.

Teachers should recognize these different intelligences and incorporate them into their lessons. They need to select a variety of problems and model solving problems using different intelligences. Helping students reach their full human potential requires a patient, nurturing educator; one with knowledge about learning theories and how to apply them and one willing to work with students in the development of each of their intelligences. Encouraging students to employ their strengths in learning situations, to develop new strengths, and to learn that others can help one develop one's strengths should be a major goal of all teachers.

Good thought provoking problems lend themselves to a variety of thinking styles and to interdisciplinary collaboration and should involve higher order thinking skills. Too often students think they are problem solving if a routine exercise is presented in paragraph form, even though no higher order reasoning is required to solve the problem.

The onus falls to the teacher to utilize a wide variety of problems to help students realize the difference between routine and challenging problems. Cooperative learning is an ideal environment for students to investigate challenging problems. Working cooperatively should encourage students to do more thinking because students can benefit from each other's ideas and start thinking about the problems more deeply. Discussing problems as a group can help students identify the important concepts necessary to solve the assigned problems.

Students need to have sufficient conceptual understanding to be able to recognize the problems we are posing. Students cannot draw conclusions in a situation where they have no frame of reference. Preschoolers can often count to 10 but they do not know how to connect this knowledge with counting objects, or they will be able to recite the alphabet but cannot identify the letters. In an article published in the journal *Teaching Children Mathematics* about children identifying triangles, third and fourth grade students were shown a poster with 10 triangles and were asked to state how many triangles were on the poster. Most of the triangles were not equilateral or right triangles and many of the students did not identify those as triangles. There was only one equilateral triangle and one isosceles right triangle in the set. Many of the students identified those two triangles as the only triangles on the poster. They could all define a triangle as a shape having exactly three sides, but did not transfer that definition to the triangles on the poster (Shifter, 1999; Strassfeld, 1999, p. 137). Students are conditioned to reason from the known to the unknown (Hume, 1995, p. 32). Consequently, students recognized the triangles that they were used to seeing. As educators we must provide

each student with sufficient exposure to all types of triangles, with different orientations, so that they can experience the long range goal Hume (1995) advocates in his assertion:

All arguments from experience are founded on the similarity that we discover among natural objects, and by which we are induced to expect effects similar to those we have found to follow from such objects. ... From causes which appear similar, we expect similar effects. This is the sum of all our experimental conclusions (p. 50).

Students do not have the same mathematical and life experience background their teachers have. Therefore, they do not have the same intellectual resources and may not approach problems the same way the teacher does. Teachers sometimes expect students to think like they do and do not allow them to think their own way. We need to be open to problem solving approaches by students that are different from those we were taught, learned and use, and we must be constantly aware of how important it is for students to try solving problems their own way. As teachers, we teach and perhaps unconsciously infuse our learning styles into our students' thinking processes. By using the same process that the teacher used, students try to please the teacher and not think about the problem in their own way. This student practice may limit the development of their problem-solving skills as well as their attitude toward and confidence in mathematics.

As teachers, we must give students time to think and not rush them, recognizing that some students need more time than others. Working cooperatively often provides students with this think time. Dewey (1991) talks about letting the students do their own thinking. He admonishes us to recognize that every student has his or her own thought

process and we must be sure to give the students adequate time and opportunity to do their own thinking and not just mimic the teacher.

### Equity Issues

NCTM, in the publication *Principles and Standards for School Mathematics*, states that we must make mathematics a reality for all students by:

Raising expectations for students' learning, developing effective methods of supporting the learning of mathematics by all students, and providing students and teachers with the resources they need. ... All students, regardless of their personal characteristics, backgrounds, or physical challenges, must have opportunities to study- and support to learn- mathematics. ... Moreover, students' learning and achievement should be assessed and reported in ways that point to areas requiring prompt attention. (NCTM, 2000, p. 12)

Equity implies that teachers set high standards for all students. Too often the expectations for students in urban schools is lower than it would be for students from schools with a much higher percentage of students who consistently test at or above proficiency level .

Low expectations are especially problematic because students who live in poverty, students who are not native speakers of English, students with disabilities, females, and many nonwhite students have traditionally been far more likely than their counterparts in other demographic groups to be the victims of low expectations. Expectations must be raised- mathematics can and must be learned by all students (NCTM, 2000, p.13).

I expect that the combination of a problem/project-based unit of instruction and technology will help provide an environment with high expectations and achievable goals for every student. It is hoped that as the students become involved in unit they will have a desire to produce high-quality projects would indicate a lack of understanding of data analysis.

## CHAPTER 3: PROCEDURES AND METHODS OF RESEARCH/INQUIRY

### Study Design

This study has a quasi-experimental pre/Post-test design enhanced by a qualitative component. A four-week unit, divided into three parts, served as the treatment for this experiment. Twelve sections of 9<sup>th</sup> grade HSPA students participated in the study. The sections were divided into four groups. One group was taught the Intervention Curriculum using the TI-84, a non-document, graphing calculator (see Appendix E for description of both calculators). A second group used the TI-84 and was taught the Traditional Curriculum. The third group used the TI-Nspire handheld and was taught the Traditional Curriculum and the fourth group used the TI-Nspire and was taught the Intervention Curriculum. There were two teachers using the TI-Nspire and one teacher using the TI-84. After the assent and consent forms were returned, the sections were assigned to the various treatment groups, with every effort to balance the numbers in each group. I am aware that there may be some variability between the groups. There was no intentional bias, no prima facie reason for bias. The classes were as equivalent as possible.

The quantitative component of this study analyzed the differences between the students' pre- and post- tests and the quantified pre- and post-attitudinal surveys. Comparisons were made among all intra and inter groups using SAS Procedures.

The qualitative component of this study was designed to look closely at students with significant mean score differences Pre-test to Post-tests and/or significant attitude

changes as reflected in their self-reported attitudinal survey responses (see Appendix C for the attitudinal survey). Students from all four groups were interviewed. It was anticipated that these students would be selected from those who returned their assent and consent forms. It turned out that, due to the limited number of forms returned, all of the students who had permission, participated in group interviews designed to give the researcher insight into the reasons the students either liked or disliked the problem/project-based approach to learning or the traditional curriculum used in his/her class.

### Data Analysis

The quantitative data was analyzed using SAS. The data was analyzed by comparing different groups, to ascertain where there were significant differences between the groups tested.

The qualitative data was analyzed to find common themes within each group and among the different groups. The teacher responses were compared with each other, and with the student responses, to ascertain common themes. The researcher compared the interview transcripts, looking for common themes, reporting what was found.

### Participants and Setting

The participants were ninth-grade students from a northern New Jersey vocational-technical high school. The school is a county school and enrolls approximately 3000 students. The student population is about 25% African-American, 60% Hispanic, 10% Caucasian and 5% other. About one third of the students are designated as special needs. Approximately 65% of the students are college bound, many



to junior colleges. The group of participants was comprised of students from ninth-grade HSPA (remedial math classes). These students were enrolled in remedial math (HSPA) for classes because they failed to pass state eighth-grade test (GEPA). This HSPA class is in addition to the students' regular math class. The majority of the students came from urban middle schools. All of the classes in this study were taught by veteran certified math teachers. Most of the students in the study were enrolled in rotating HSPA math and HSPA language classes. These students had HSPA math marking periods one and three and HSPA language arts marking periods two and four. The students who were in non-rotating classes had HSPA math all year long. Written permission to use the site and the ninth-grade students was granted by building level administrators. Approval of the study's methodology was obtained from Montclair State through the Institutional Review Board.

### Instruments

Proficiency on the Data Analysis Cluster of the HSPA was measured before and after the treatment period. The instruments used for this purpose were compiled using several resources, including questions from the state and from commercial HSPA workbooks. Both the Pre- and Post-tests included questions that assessed student's ability to recognize important concepts and to apply them to new problem situations. The goal of the assessment was to measure student's conceptual and procedural understanding of data analysis (see appendixes A and B for the Pre-test and Post-test).

Mastery of the concepts and related tools was to be measured by the richness of the final projects (this did not happen due to assent consent form, explained in the next

section); teacher and student interviews and survey questions (see Appendixes D for the interview protocols). The class work and projects demonstrated the correct use of terms and analysis of data. Teacher input provided information about changes in students' ability to compare and contrast sets of data and the mastery of concepts and helped to triangulate data.

### The Instructional Curriculum

#### *Intervention Curriculum*

The instructional unit in this study was created and compiled by the investigator (see Appendix F for a transcripts of the project). The data in the first problem looked at population data for the United States, New Jersey, Passaic County, N.J. and Paterson, N.J. Students compared and contrasted the data by ethnic groups. The data used in the second problem focused on wages for sixteen to twenty-four year olds, delimited by gender and ethnicity. Comparisons between different groups encouraged students to analyze different sets of data and to rearrange the data sets for better analysis. Students tried to discern why there were differences between several groups. Using the wage data from this problem, the students had the opportunity to select groups they wished to compare and to create a small project based on their selection. Finally, students did a project exploring wage and employment statistics for the particular career they are preparing to enter. Students were grouped by their intended, self-selected, career areas such as construction jobs, health care workers, automotive, cosmetology, etc. The exact grouping was determined by the representation of career interests in each class. The unit was designed so that students would have the opportunity to follow the guidelines

suggested by Scheaffer and Tabor in the Guidelines for Assessment and Instruction in Statistics Education (GAISE) report.

- Conceptual understanding takes precedence over procedural skill.
- Active learning is the key to the development of conceptual understanding.
- Real-world data must be used whenever possible in statistics education.
- Appropriate technology is essential in order to emphasize concepts over calculations.
- All four steps of the investigative problem-solving process should be encountered at each grade level.
- The illustrative investigations should show situations in which the statistics are essential to answering a question, not just an add-on.
- Such investigations should be tied to the mathematics they illustrate, motivate, and emphasize (Scheaffer & Tabor, 2008, p.57).

Although the students did not actually collect raw data they had to find data about their prospective careers. They used data, which had been collected by federal, state and local agencies such as the Bureau of Labor and Statistics, the New Jersey Department of Labor and county labor statistics.

### *Traditional Curriculum*

The topics covered in the Traditional Curriculum of instruction were the same as those covered in the Intervention Curriculum. The traditional group used Glencoe's textbook Mathematics Applications and Concepts, Course 2. This was supplemented with

problems from various HSPA preparation workbooks. Because the same teachers were teaching both the Traditional and Intervention groups, they taught the same concepts in all classes. The difference was the use of many varied problems versus questions dealing with the same data sets.

### Variables in the Study

#### *Independent Variables*

One of the independent variables was the instructional method, Intervention Curriculum or Traditional Curriculum. The other independent variable was the calculator used, TI-Nspire handheld with its document features or the TI-84 calculator. The teachers who participated in the Intervention groups participated in training on the handheld and on the project unit.

Both teachers using the traditional curriculum prepared their lesson plans together so the material used in all the traditional classes was the same. The students also had instruction with the TI-Nspire prior to the start of the Intervention Curriculum. However, the rotation of classes meant that the students had not used the TI-Nspire for the 10 weeks prior to the beginning of the study.

The Control group was taught the Traditional Curriculum of instruction using the current curriculum and the TI-84 calculator. The TI-84 is the standard calculator assigned to each student at the research site. One experimental group was taught the Traditional Curriculum of instruction using TI-Nspire calculator. Another was taught the Intervention Curriculum using the TI-84. The fourth group was taught the Intervention Curriculum using the TI-Nspire. Figure 3.1 shows what Curriculum and calculator each of the four

groups used.

Instruction	TI-Nspire	TI-84
<b>Intervention Instructional Unit</b>	Group E1	Group E2
Number (classes, students)	(4,45)	(3,24)
Teacher	B and C	A
<b>Traditional Instructional Unit</b>	Group E3	Group (C)
Number (classes, students)	(3,41)	(3, 32)
Teacher	B	A

Figure 3.1 Experimental and Control groups

### *Dependent Variables*

The dependent variables are the Pre-test and Post-test results and attitudinal survey results. Results of the student and teacher interviews were triangulated with the results of the pre- and Post-tests and the attitudinal survey.

### *Procedure*

After the groups were assigned, students were given a Pre-test and the attitudinal survey (see appendices A and C for the instruments used). These were monitored either by me, or by one of the participating teachers, monitoring a class other than their own. All of the Pre-tests and attitudinal surveys were returned to me in sealed envelopes. I graded all of the tests and recorded the student responses to the attitudinal surveys. I also had two other teachers grade the Open-ended questions to assure there was no bias in the grading. Students who were not participating in the study had the option to take the Pre-test and survey or do an alternative educational activity. Those who chose to take the Pre-

test and survey knew that their results would not be included in the data analyzed.

Following the initial testing, all classes were taught their assigned instructional unit. The unit took longer than expected, but since both the Traditional Curriculum of instruction and the Intervention Curriculum of instruction both needed additional time, all teachers finished the unit at about the same time.

At the conclusion of the unit, all groups were given the Post-test and repeated the attitudinal survey (see appendices B and C for the instruments used), following the same procedures used at the beginning of the unit. The students were asked if they would be willing to participate in group interviews and to have their work looked at. Many students said they were willing, but getting permission slips back was a challenge. Most of the students had switched classes (because the marking period ended) before they brought their permission slips back. The new teachers continued to ask for them, but few students returned them. As a result, I was not able to be selective in choosing groups, as planned, and was not able to look at student work, because I did not have permission from all members of the project groups. (The projects were all group projects and in order to look at them I needed permission from every student in the group.) The teachers were able to describe them to me. The students interviewed were the ones willing to participate. It was almost a month after the conclusion of the unit before I had enough permission slips to conduct the interviews. By then the students seemed to have lost their enthusiasm for the unit of instruction. Their answers were short and not very descriptive, despite prodding questions from me.

Teacher interviews were more helpful. Although I could not look at student work,

the teachers provided valuable insight into the quality of the projects. They also provided information about how the presentations demonstrated the students' different learning styles.

### Ethical issues

Serious consideration was given to the ways this study could affect the students involved. One precaution employed was to allow the participants to withdraw from the study at any time. Students were also told that they did not have to answer any question on either the Pre-or Post- test or the survey instrument they were not comfortable with. As the study involved children under the age of 18 informed assent from the students and informed consent from their parents or guardian were obtained prior to the collection of data. Those documents informed both participants and their parents of the general aim of the study and how the study would be conducted. Separate assent and consent forms were obtained from all participants who were interviewed.

### *Trustworthiness*

All studies face questions about the trustworthiness of the study. According to Guba and Lincoln (1985) there are four criteria for evaluating the trustworthiness of a study: credibility, transferability, dependability and confirmability.

#### *Credibility.*

Credibility is the extent to which the findings reflect the phenomenon being studied. Triangulation between the quantitative and qualitative findings help increase the credibility of this study. According to the Robert Woods Johnson website *Qualitative Research Guidelines Project*, "Triangulation involves using multiple data sources in an

investigation to produce understanding” (Cohen & Crabtree, 2006, ¶ 1). “A single method can never adequately shed light on a phenomenon. Using multiple methods can help facilitate deeper understanding” (Cohen & Crabtree, 2006, ¶ 3). Triangulation involves checking the consistency of findings generated by different data collection methods. By having both quantitative and qualitative data in a study one can “elucidate complementary aspects of the same phenomenon” (Cohen & Crabtree, 2006, ¶ 5). The quantitative data was collected by the researcher to eliminate teacher contamination of the data. The Open-ended questions were graded by me and two other teachers. A rubric was followed to assure consistency in scores. All interviews were conducted by me and students knew that anything they said to me was not going to be repeated to their teacher. All interviews were audio taped to assure accuracy in reporting student and teacher responses.

#### *Transferability.*

Transferability is the extent to which the findings of this study are applicable to other settings. The main strategy to increase transferability is to provide detailed information about the study site, the participants and the findings (Marshall & Rossman, 1999). By comparing the reader’s site to the study site, the reader should be able to decide if the findings are applicable at their site. I have included detailed information about the study site, and the data collection and analysis methods used in the study to help the readers decide if the findings are transferable to their site.

#### *Dependability*

Dependability relates to the extent to which the research process is trackable and



documentable. “Dependability is achieved through a “dependability audit” which includes construction and maintenance of an archive facilitating access to all documentation as well as a running account of the process of inquiry in the form of researcher logs” (Twining, 1999, ¶ 25). To increase the dependability of this study, I maintained a file containing the data instruments, Pre-and Post-test, Pre-and Post-surveys, and audiotapes of the interviews with students and teachers. The statistical analyses were also kept.

#### *Confirmability.*

Confirmability, according to Marshall & Rossman (1999) is the extent to which the data helped confirm the general findings and conclusions of the study and help lead to the implications drawn by the researcher. “Confirmability is achieved when constructions, assertions, and facts can be tracked to their original sources and when the logic behind their construction leads to an explicit and implicitly coherent and corroborating whole” (Twining, 1999, ¶ 26). Analysis of both the qualitative and quantitative data enhances the confirmability of the study. Transcripts of the qualitative data and inclusion of the statistical results assure accurate analysis of the data. Multiple graders assure consistency in the grades of the Open-ended questions. Common planning assured that the Traditional Curriculum used in those groups was the same. The Intervention Curriculum was scripted for both types of calculators to assure uniformity in the content.

#### Limitations of the Study

Because of the uniqueness of our student population, the study is limited in its

generalizability. As explained before, the researcher took safeguards to maximize the reliability and validity of the findings. However, student familiarization with the calculators they were using had an impact on the study results. Students with more experience using the various calculators may very well have performed differently on the project. The teachers in the study were chosen because of their expertise with the calculator they were assigned and their expertise in teaching HSPA. Every effort was made to make the groups as balanced as possible.

## CHAPTER 4: ATTITUDINAL CHANGES

This chapter examines the research question: What is the effect of using problem/project-based learning on students' attitude towards mathematics and data analysis? Both qualitative and quantitative study results from the interviews and attitudinal survey are presented. The qualitative data is presented first, starting with a description of how that data was collected, categorized, and analyzed. Following the analysis of the teacher and student interviews are the findings of the quantified self-reported data from the attitudinal survey. After a description of how the quantified survey data was analyzed, the results are discussed by category and then by individual statements within each category of questions.

### Qualitative Research Results

At the end of the instructional unit, each of the participating teachers was interviewed individually. The teacher interviews were conducted shortly after the unit is completed. Their responses are discussed according to the groups they teach. Teacher interviews are summarized first. I elect to analyze the teacher responses first because they help illuminate the student responses.

As noted in chapter 3, there were problems getting permission to conduct the interviews so the student interviews did not take place until a month after the instructional unit was finished. There were four student interview groups, representing the Control group and each of the three experimental groups. Each of the interview groups had students from more than one class. The students were not very responsive, possibly because they did not know me. I assured the students that no one would know

what was said. Their answers were not as descriptive as I had hoped they would be.

Each of the interviews was tape-recorded and later transcribed by the researcher. The data was categorized and analyzed according to common themes in student responses. Following the student interviews, is a summary of the overall findings. Masculine pronouns are used for all of the students and teachers, regardless of their actual gender.

### *Teacher Interviews*

There was only one teacher using the TI-84. The students in his classes had been using the TI-84 for a full semester (2 marking periods) in their algebra class and had used it for the first marking period in their HSPA class. Some of the students had not used the statistics features of the calculator prior to the start of the unit. This teacher taught both the Traditional and the Intervention Curricula. He felt that the Control group did not get bored while the Intervention group did. "As ninth-grader's they were not interested in critical analysis, but did appreciate the comfort level achieved by using the same type of data, but they also got bored with it. Comfort and non-boredom is hard to accomplish with ninth graders. Most of the students did not care enough to want to analyze the data." Perhaps because of this general lack of interest neither of his groups was particularly good at conducting a critical analysis of data. Perhaps the teacher did not encourage critical analysis.

This teacher did not feel that there was a difference in the learning between the two groups. The Control group did not do much comparison of data because each problem was different. Some of the problems did require analysis but nowhere near as

much as the problems done by the Intervention groups. He felt that his Intervention group, while they did get bored at times, did become very familiar with and comfortable with the data. “The students learned by using the same set of data. It provided some benefit because they could see into the numbers more clearly despite their boredom at times. When they did compare the data sets they were able to see differences, noting the great differences between the wages of the different ethnicities as you move from national to state to local populations.” The students using the TI-84 in both groups were at a disadvantage in comparison to the groups using the TI-Nspire because they had to draw the circle graphs by hand. He felt that the Intervention Curriculum would have been more successful if it had been used with older students. The teacher concluded the interview by stating that he is an advocate of project-based learning in a student-centered atmosphere. “It is important to get the center of attention off the teacher and onto the student.”

At a later date I asked him about the student projects. He said that the groups did a good job of presenting their data. The variety of approaches used demonstrated that the groups had employed the talents, and learning styles, of each group member. Some groups prepared posters, others did power-point presentations. In some groups everyone explained part of the project while in other groups one person had been delegated the speaker.

Two teachers used the TI-Nspire. One of the teachers had students who stayed with him the second marking period. Therefore, his students were more familiar with the calculator than the students who had switched classes. This teacher taught only the TI-

Nspire Intervention group. The second teacher, whose students changed at the end of the first marking period, taught both the Traditional Curriculum and the Intervention Curriculum. Many of the students who were using the TI-Nspire in their HSPA class (where the data analysis unit was used) switched the calculator face to the TI-84 in their algebra classes. (The TI-Nspire comes with two faces, the TI-Nspire face and a second face that transforms the handheld into a TI-84 calculator.) Therefore, they had not used the TI-Nspire for an entire marking period and were at a disadvantage at the start of the unit. Most of the students were not familiar with the statistics features of either calculator. The teacher whose students had changed classes felt that the lack of calculator skills got in the way of learning in all of his classes, not just those classes that were in the study.

The teacher who taught both groups said, “They learned more of different things. The experimental [intervention] group learned more about how to use the calculator and how to just basically master the calculator. As for the material, both groups learned the same amount. The experimental [intervention] group had the advantage of learning about the calculator and the material.” “Their lack of calculator skills got in the way of learning. I had to walk them through each step. It could not be independent learning because once they did the first set of data and were ready for the next set, they had forgotten how to do the spreadsheets and scatter plots. By the third set, they were getting more independent. If they were more proficient with the calculator, they could have gone through the project on their own.” The teacher whose students had used the calculator all year said, “The students were comfortable with the calculator but they had not seen how to use it to find the line of best fit.” They had drawn approximate lines of best fit by hand

but had not made predictions using their line. They were okay in terms of using the calculator but not in terms of finding the line of best fit. It was new material.” The other teachers also commented that finding the line of best fit was new to their students.

The TI-Nspire has a document feature, an integral part of the Intervention Curriculum. According to the teachers, some of the students liked being able to take notes and answer questions on the calculator. Others hated it. One teacher said, “One period loved it but the small group [class] did not like it.” The other teacher said, “My students do not like to write anyway. It [the notes feature] helped [them] to read it [the Intervention Curriculum] but not to write it. They liked it for getting directions but not for answering questions. The instructions were in the handheld and that was comfortable for the students. They could go back to another page and that was good.” Depending on the level of the students, maybe the handheld should not be used for answering questions. If the students cannot easily manage working on the handheld and are more successful writing in a notebook, that might be the best. Flexibility is important.

One of the teachers said that his students had a hard time finding their own data for the project. “If the students had been able to collect more of their own data it would have been better. They really enjoyed trying to find their own data, but [they] had trouble finding enough data. The data they did find they were able to get into the spreadsheet and were able to create the line of best fit. They knew how to look for data, but were stuck for three days searching for interesting data relating to their individual occupations. They got discouraged when they could not find exactly what they were looking for.” The other two teachers did not say anything about difficulty in collecting data but their students did. It is

important for teachers to recognize the impatient nature of teens. We may have to make it easier for students to find the data by supplying specific web sites to try. All the data was supplied for the Instructional Curriculum and the students were looking for similar data for the project. The same type of gender and ethnicity data was not available for individual occupations. Instead of deciding to use the data available to create their project, the students kept looking for exactly the same type of data they had used in the problems done as a class. They did not have the creativity to, or knowledge that it was okay to, or maybe the desire to create their own type of project.

Both TI-Nspire teachers felt that ninth graders were not as interested in the project as they would have been as juniors or if they had been in a statistics class. They claimed that at the junior level students would see more need for becoming proficient at analyzing data. This agrees with what the teacher using the TI-84 said, as mentioned earlier in this chapter. Despite the lack of motivation, both teachers later reported that the projects demonstrated mastery of the concepts from the unit. They both said that the projects allowed the students to use their personal learning strengths. Their comments were very similar to those of the teacher using the TI-84 (already mentioned).

### *Student Interviews*

#### *Control group.*

The Control group was most comfortable with scatter plots and stem and leaf plots. One student said, "I like pictures, so it is easier to do a stem and leaf plot. I can write it out quickly." A second said, "I like it all." A third said, "I don't have a problem with none of it." Another student said, "You can't predict from a stem and leaf plot." This



led me to ask what they knew about predicting from graphs. One student said that it was easy to predict from a bar graph. He said, "If the bar graph is going up evenly you know what it is doing so you could predict." Another said, "The line of best fit is easy to draw and easy to predict with. Just plot the points and draw the line." The students said that they drew the lines of best fit both with the calculator and by hand. Most of the students said that they liked drawing the lines of best fit with the calculator. But one said, "You don't learn as much if the calculator does it for you." In response to my question, "In real life will you be doing more drawing of graphs or interpreting them?" One student felt that in real life, "We will be interpreting graphs more than drawing them. Letting the calculator do the work helps." "It makes life so much easier if you don't have to do all the work."

From their responses it was evident to me that the students had mixed feelings about using technology to assist them in interpreting data. They were afraid that they would not be able to create graphs on their own. Just prior to the interviews the students had been informed for the first time that they would not be able to use calculators on their final exam, and they were concerned about their ability to perform without them. (Because of the way exams are administered at the study site, it is logistically impossible to get the calculators back after exams, and therefore all exams are written to be non-calculator exams. Some courses give a calculator piece in class prior to the start of exams.) Although the students were not very talkative, I got the feeling that they understood the basics of data analysis because the students were able to discuss the various types graphs and when one graph would be better than another.

The students liked having a variety of problems, but felt that some in-depth analysis of the same data would also have been nice. The students felt that they had learned what they needed for the HSPA and that they had learned how to interpret as well as how to draw graphs. One student said, "I learned about the importance of scale when drawing graphs." Another said, "I am still bad at scatter plots. We all know how to do it but are lazy and it's hard to keep track of what you have plotted and what you have not done yet. It would be nice if the data was in order for us."

Most of the students said they were more confident with Open-ended questions than they were at the beginning of the unit but one student said, "I just get nervous as soon as I see an Open-ended question. It's like writer's block." The students were quite confident about deciding what type of graph was appropriate for a problem. "You use circle graphs for percentages, like breaking up the day for a survey of interest." "You use a bar graph for money earned." "Scatter plots are best for comparing data and predicting." One student said, "A line graph is a line of best fit." Another corrected, "No. The line graph is connecting the points and a scatter plot is used for the line of best fit." When asked about circle graphs most of the students said that they were time-consuming and somewhat difficult to do by hand. However, one student said, "Circle graphs are easy to draw by hand. Just divide the circle into  $180^\circ$  on each side and then  $90^\circ$  and estimate the rest. It is easy." Another stated, "Use a protractor, if you have one."

When asked if they thought that being able to take notes and keep their work from day to day would be a good feature to have on a calculator. One student said, "It would be a help to be able to go back and look what you did before." Another said, "It would be

a good study tool.” A third said, “I do not use a calculator that much. I would rather do it all by hand.” These conflicting responses are not surprising given that the calculator the Control Group students used (the TI-84) does not have this feature.

*TI-84 intervention group.*

This group was most comfortable with bar graphs and scatter plots. Most of them did not like circle graphs. One student said, “They are a lot of work.” One of the students said that circle graphs were okay.

Some of students felt that the project approach helped them. “We liked having the same data with different types of graphs.” However, another student said, “I hated it. I did not learn anything new. I knew it all before.” Another student said, “At times it was very confusing in terms of material. The calculator was easy.” Most of the students said that they had never seen a line of best fit before the project. During the project, they drew the line of best fit by hand and with the calculator. One student said that he did not like doing it on the calculator. When asked why, he responded, “When you draw it with the calculator you do not have to do any thinking. Besides, it is easy to draw by hand.” All of them admitted that when they draw a line of best fit by hand they could not find the equation of that line. Although the students said that in the future they would be interpreting data, rather than drawing it, they were concerned about becoming reliant on the calculator. “When you don't have a calculator you will have to be able to draw by hand.” One student said that in order to interpret data you don't have to be able to draw the graph. “Most of the time graphs will already be there for you.”

These students were asked if they thought that being able to take notes and keep

their work from day to day would be a good feature to have on a calculator. One student said, “Yes, it would help to be able to go back to the graphs you did yesterday.” “We would like to have everything in one place.” “Having notes would be nice.” “No. My friend says that it is hard to go back” (The student is referring to going back on the TI-Nspire.)

I felt that the confusion with the unit of instruction focused on the mechanics of putting the data into the calculator, that is, with data entry. The unit of instruction included detailed descriptions of how to enter the data, but the students got confused trying to follow all the details. They also got tired of having to enter the data all the time. Most of the students did not like having to draw the circle graphs by hand, it was too much work.

*TI-Nspire traditional group.*

Two students in this group said they were most comfortable with bar graphs, two said box and whisker plots, and one said scatter plots. One who liked the box and whisker plot said, “It tells the mean and median, and it is easy to draw.” One of the students who liked the scatter plot said, “They are easy to graph. All you have to do is put the points on the graph.”

All the students thought that data analysis was “cool.” Most liked using the calculator, but one said, “I would rather draw graphs by hand because I understand it when I do it by hand even if it's wrong, and I have to correct it. I do not know what's going on if I use the calculator.” Most of the students felt it was easier to interpret data when the calculator draws the graphs for them, but one student said, “It may be easier for

you if the calculator does it, but you don't have to know what you're doing.” One student pointed out that graphs are more accurate when drawn on the calculator than they are when drawn by hand. Another student objected, “You have to know how to do them by hand, because depending on what type of work you do, maybe you'll have to create graphs such as profits or sales over time.” Another student pointed out that they would probably not be creating them by hand anyway. “You would either use a computer or pay someone to create graphs for you.”

The students said they had done scatter plots before but never on the calculator. Most of the students in this group said that they had not done lines of best fit before. Two of the students said they had done them by hand, but never on the calculator. None of them had ever made predictions from a line of best fit. (Note: The line of best fit is on the HSPA, but most of the middle schools the students came from did not get to this topic.)

Most of the students in this group reported that they liked being able to go back and look at graphs they created or had seen before. However, they did not like taking notes on the calculator. “It takes too long. The keys are too small.”

A variety of problems were done by this group. “We used problems from the book and some from a packet.” “We did circle graphs and scatter plots,” “We did circle graphs by hand at the end, a lot of people got a hundred.” They liked having a variety of types of data in their problems but said that using the same data would make it easier to learn how to compare things.

This group was quite comfortable with the TI-Nspire. The Traditional Curriculum was not as calculator intensive as the Intervention Curriculum. The students in this group

did not seem to have the same frustration with the TI-Nspire and the students in the Intervention groups did. These students did like being able to go back and look at their previous work that had been saved on the TI-Nspire, but they did not take advantage of the notes features of the calculator. As noted above, the students felt that taking notes was too time-consuming and the calculator keys were too small.

*TI-Nspire intervention group.*

In this group three people said they understood bar graphs best, one said he did not know what type of graph he understood best and the rest said, “All graphs.” When asked about circle graphs, the students said that they did not understand them. When questioned further, most of them said that they did not like to draw circle graphs but were good at interpreting them.” The calculator makes it easy to draw them.” Another student said, “pie charts are so-so on the TI-Nspire. It is difficult because of the buttons.” When asked for clarification about the buttons, the student said, “It is hard to remember what you have to do.” “It was easy to create the lists to create the pie chart.”

At the start of the study the students in this group were not as familiar with their calculators as they should have been. If similar studies are conducted in the future, it is strongly suggested that the participants should be more proficient with the calculator before starting the unit.

When asked if they could do scatter plots, one student said, “Yes, but I do not like to because it is too complicated.” The other students agreed. One student said, “Too scary.” However, the same students were able to describe how to draw the line of best fit. One student said, “Draw through zero and through the center of the data.” Another

student said, “It does not always go through zero, but goes through the center of the points.” “It is easy to draw by hand, but not to get the equation.” The students did not know how to get the equation by hand, but they did know how to get it on the calculator. The students said that they were pretty good at comparing and contrasting graphs. The students appeared more knowledgeable than they thought they were. They did not feel confident with the line of best fit, although most could accurately describe how to draw it and how to use it to predict future values. The line of best fit was new for all of the students that may account for their lack of confidence.

When asked about the document features of the TI-Nspire, the students said, “You could look back, but you had to press too many keys to go back, so half of us did not go back, but the half that did go back found it helpful.” The students did not like taking notes on the TI-Nspire. “It takes too long, because the buttons are so small.”

The students did not feel that the material was different from other years.” We did not learn new material, but we sure learned the calculator.” The students felt that if they had the calculator all year without a break it would have made a difference. “We forgot a lot. We were concentrating on the calculator, not on the material in the unit.” Some of the students in this group did not change their HSPA class for marking period two (they had HSPA math all year) so they did not have an interruption in calculator use. They said that they were comfortable with the calculator, but not with the data analysis features of the calculator.

When asked about the unit of instruction, one student said, “It was nice having the same type of data.” Another said, “It got boring.” Another student said, “I would have

liked to enter my own data, instead of having it already entered for me.” When asked about the project portion of the unit the students responded, “It was hard to find the data, so we did not like doing the research. If we could have found what we wanted to find, it would have been more fun.” “We could find wages, but not specific for our shops.” “We had a list of websites, but it was hard to find the data we needed.” When asked if they liked looking for their own data one student said, “Not really. I would have liked it if I could have chosen my topic for the project.”

When asked if using the calculator to do the drawing was helpful they responded, “The calculator is faster and more accurate. By hand you learn how to draw and have to concentrate more.” “In real life you will spend more time interpreting graphs so it is more important to be able to interpret graphs than to draw them.” They felt that they needed to know how to interpret statistics that they found in newspapers and magazines. “It is important to be able to understand charts. They are not always accurate, because data can change. It is not accurate if the graph does not change.” “People can manipulate the chart by changing the scale to mislead the data.” One student said that he did not think that data analysis was important for the HSPA, because he did not remember seeing it on the practice test. The others said they thought it was on the test. (Very often one of the Open-ended questions is a data analysis multi-part question.) When asked about using the calculator one student said, “For general work, computation, I would rather do it by hand. To graph [using] the TI-Nspire is much easier than the TI-84, because the equation is right with the graph.” This feature is not on the TI-84. On the TI-84 putting the line of best fit on the graph takes multiple steps using multiple menus. Another said, “It is easy



to do the work, but I would rather do everything by hand.”

### Summary of Interviews

Several themes emerged from the student interviews that were also supported by the teacher interviews. I identified those themes as:

- Student understanding of data analysis
- Creating graphs by hand versus using the calculator
- Student readiness for project-based learning
- Academic maturity of the students
- The Notes feature of the TI-Nspire
- Calculator skills for the TI-Nspire groups

These themes are intertwined in the following discussion of the student and teacher interviews.

Most of the students in all of the groups felt that they understood and were comfortable with data analysis. The teachers felt that the students understood the basics of data analysis, but lacked the academic maturity to thoroughly compare and contrast data.

The majority of students agreed that it was nice to let the calculator do the work, but some of the students felt that it was also important to be able to do it by hand. This is something teachers must consider, how much should students do by hand before allowing technology to do it for them? As teachers, we need to find the balance between the amount of hands on calculation and the use of technology.

The students in the Intervention Curriculum groups found that the unit was too

repetitive, although most agreed that by the end they were very comfortable with comparing different sets of data. Because the students lacked academic maturity, they did not have the ability to really compare and contrast the data, so they saw the exercises as repeating the same thing over and over. In contrast, the students in the Traditional Curriculum groups liked having the variety of problem sets but would have enjoyed some in-depth analysis. They felt that using the same data to do multiple comparisons would have been nice.

Most of the students said the project they had to on their own was very difficult, because they could not find the data they wanted for their individual occupations. They could find general data, but the data was not broken down by gender and ethnicities. This was frustrating to them. Some students said that they would rather have picked their own topics for the projects. This points to the students' lack of familiarity with project-based learning and the lack of maturity to design their own project, rather than imitating the one done together.

Normally, in a project-based unit the students would pick their own topics. I thought that because every student in the school is preparing for a career, using data about their own careers would allow enough individuality, but the lack of easily accessible data stifled the students' creativity. The students were easily frustrated when they could not find the data for their individual occupation organized in the same manner as they had used in the unit problems. Future projects need to consider the advantages and disadvantages of allowing more student decisions about what they investigate.

The students who used the Traditional Curriculum of instruction said that they did

not compare data a lot. They said they had individual questions about a set of data, but did not have the opportunity to create their own comparisons. Most of them like having a variety of types of data. Some of them said that it might have been nice to work with a set of problems that made use of similar data sets.

Students using the TI-84 found the calculator easy to use even though they had to draw all of their circle graphs by hand (the TI-84 does not have this function). Some felt that it would have been nice if the calculator had drawn those graphs for them. Others said the circle graphs are easy to do by hand so they did not care to that their calculator did not draw circle graphs.

In contrast, students using the TI-Nspire found the calculator difficult to use. Some of the students appreciated having the data already in the calculator and others felt that they would rather enter the data by themselves. Most of the students did not like having to write answers in the calculator, because it was too time-consuming. They found the keys too small, making it hard to write quickly and reported that their speed of writing was also hampered by the arrangement of the keys, alphabetically instead of QWERTY. Some of the students liked being able to go back to look at prior work and at prior instructions, but others felt that it took too much time. The length of the problems may have been a contributing factor. Because the entire Intervention Curriculum was on the TI-Nspire, each problem had approximately 30-50 calculator pages. (A calculator page is about 15 - 20% of a printed page. The problem is navigating between them without the aid of any indexing feature.) The students were not proficient at negotiating through that many pages to find the data they wanted. There are many shortcuts, but the

students were not comfortable enough with the TI-Nspire to be able to use them.

The teachers using the TI-Nspire discussed the difficulties encountered by the students as they tried to negotiate the unit without being completely comfortable with the calculator. They agreed that the students did not like taking notes on the calculator because it was too time consuming, but they felt that the students liked being able to go back to previous work to compare and contrast their graphs. The teachers believed that the reasons some of their students found that the Intervention Curriculum boring was related to their lack of mental maturity and interest. They felt that the students would have gotten more out of the unit if they had been juniors or enrolled in a statistics course.

#### Quantitative Results for the Attitudinal Survey

The attitudinal survey was administered before the unit began and again immediately after the completion of the unit. The attitudinal survey had 40 statements, divided into six categories as follows: (see Table 4.1).

Table 4.1

##### *Categories of Attitudinal Statements with Statements in each Category*

Category	Statements in Category
Open-ended Questions	Statements 1 - 9
Percents	Statement 10
Interpreting Statistics	Statements 11,12,15,16,29,30,32
Creating Graphs	Statements 13, 14,17-19, 24- 28, 31
Basic Statistics	Statements 20-23
Interpreting Graphs	Statements 34-40

Student self reported responses were quantified for analysis. Student response choices: *strongly disagree*, *disagree*, *agree*, *strongly agree* were translated into the numbers one through four with four being strongly agree. The results reported are the changes in mean scores within each group from before to after the unit of instruction. In the discussion that follows, “changes” will refer to “difference (post-test - pre-test) in the mean scores” of a group. SAS was used to analyze the data. The null hypothesis was: the responses to a survey statement or group of statements were the same before and after the unit of instruction. The null hypothesis was tested under the assumption that the null hypothesis was true and the sampling distribution was known, in this case with  $\mu = 0$ . Thus it was possible to compute the probability ( $p$ ) of obtaining a sample mean that was as far, or further, from the population mean of 0 as the observed value of  $\bar{x}$ . If  $p$  was less than or equal to a preselected value  $\alpha$  we said there was evidence against (or reject) the null hypothesis. This study used the customary value of  $\alpha = .05$ . When the  $p \leq .05$ , we said the observed change was statistically significant. Or, in other words, the change in the mean responses from before the intervention to after the intervention was statistically significant. Although statistical significance was determined with respect to  $\alpha = 0.05$ , there were different strengths of significance. If  $p < 0.01$  was regarded as strong evidence against the null hypothesis. If  $0.05 \leq p < 0.10$  we said that, although the result was not significant, there was weak evidence against the null hypothesis. Significant changes are positive changes in student responses unless otherwise noted. Weak, non-significant changes are included in the discussion. Table 4.2 presents the four basic groups E1, E2, E3 and C from which all the other groups studied (referred to as cohorts) were formed.

Table 4.3 presents the eight cohorts studied. Subsequent tables include only the groups and cohorts for which there were significant or weak, non-significant changes in student response.

Table 4.2

*Structure of the Instructional Groupings*

Group	Instruction	Calculator	Classes	Students	Teachers
E1	Intervention	TI-Nspire	4	45	B , C
E2	Intervention	TI-84	3	24	A
E3	Traditional	TI-Nspire	3	41	B
C	Traditional	TI-84	3	32	A

*Note.* Classes indicates number of classes and Students indicated total number of students in each group

Table 4.3

*The Eight Cohorts in the Study*

Group Abbreviation	Group Participants
TI-84	TI-84 (E2 + C)
TI-N	TI-Nspire (E1 + E3)
Trad	Traditional Curriculum (E3 + C)
Inv	Intervention Curriculum (E1 + E2)
C	Control
Exp	Experimental (E1 + E2 + E3)
Grp3	Trad + TI-84 Exp (E2 + E3 + C)
E1	TI-Nspire and Intervention (E1)

The change in the self-reported attitudinal responses for the entire Attitudinal Survey, by each of the study groups, is presented in Table 4-4 and then briefly discussed. That is followed by a discussion of the change in responses to sets of statements grouped by categories and by individual survey statements within each category. Only statements for which there was a significant or weak, non-significant change in student response are discussed.

Table 4.4

*Codes used in the Tables and Figures for Chapters 4 - 6*

- SD ↔ Standard Deviation
- M ↔ mean difference
- **bold P-values** ↔ significant( $p < .05$ ) showed positive change in attitude
- Underlined  $p$  values ↔ significant, showed negative change in attitude
- *Italicized P-values* ↔ weak, non-significant
- $p$  ↔ P-value
- N ↔ number of students in the group who responded to both the pre-and post-test questions, not necessarily the same as the number in the group

All of the cohorts in the study, except the Control group and the TI-84 group, recorded statistically significant changes in their attitudes before to after the instructional unit of study (see Table 4.5). The following analysis of the responses to the different categories of statements, and to individual statements in the survey provides some understanding of the reasons for these observed changes

*Category 1 – Open-ended Statements (Statements 1-9)*

The first nine statements on the attitudinal survey all referred to student's opinions about Open-ended questions. The students using the Intervention Curriculum (E1 + E2) showed evidence of significant changes in attitude (see Table 4.6). The students in the Experimental (E1 + E2 + E3) group showed weak, non-significant evidence of change.

Table 4.5

*Difference in Mean scores (Post-test – Pre-test) in the Total Quantified Scores for the Attitudinal Survey*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
TI-84 (E2 + C)	54	0.06	0.27	.13
TI-N (E1 + E3)	82	0.15	0.28	<b>&lt;0.0001</b>
Trad (E3 + C)	67	0.11	0.33	<b>.01</b>
Inv (E1 + E2)	69	0.12	0.22	<b>&lt;0.0001</b>
Control ( C )	30	0.00	0.29	.93
Exp (E1 + E2 + E3)	106	0.15	0.27	<b>&lt;0.0001</b>
Grp3 (E2 + E3 + C)	91	0.11	0.31	<b>&lt;0.0001</b>
E1 (E1)	45	0.12	0.22	<b>&lt;0.0001</b>

*Note:* N ↔ number of students in the group who responded to both the pre-and post-test questions, not necessarily the same as the number in the group.



Table 4.6

*Results of Statistical Analysis of the Change in Responses to Statements in**Category 1: Open-ended Statements*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
Inv (E1 + E2)	69	0.08	.26	<b>.02</b>
Exp (E1 + E2 + E3)	106	0.06	.32	<b>.04</b>

The Intervention Curriculum group (E1 + E2) spent a lot of time answering Open-ended questions about the data they were working with, so a change in attitude in this category was expected. When this group was combined with group E3 to form the Experimental Group, for this category of statements, the change was still significant, but not as strongly. This decrease in significance may have been because the Traditional Curriculum did not focus on Open-ended questions as intensively as the Intervention Curriculum. The Pre-/Post-test analysis discussed in Chapter 5 indicated that students in the Traditional Curriculum (E3 + C) group outperformed the students in the Intervention Curriculum (E1 + E2) group on the Open-ended questions. Attitudinal changes were not necessarily reflected in Pre-test to Post-test scores.

In responding to the statement, “Teachers explain Open-ended questions very well” (see Table 4.7) the mean scores of students in the Intervention Curriculum (E1 + E2) and the Intervention TI-Nspire group (E1) showed significant evidence of a negative change in attitude. This means that the self-reported attitudinal responses were less favorable on the post-test than they were on the pre-test. The weak, non-significant

change for the TI-Nspire was probably influenced by the attitudes of the students in the Intervention TI-Nspire (E1 group).

This was not surprising because the Intervention Curriculum of instruction was less teacher-centered than the Traditional Curriculum. Students who were used to teacher-centered instruction may have misinterpreted the shift to student-centered instruction as an indication that the teachers were not explaining the material. The attitudes of the students in the Intervention group seem to have affected the TI-Nspire group results.

Table 4.7

*Results of Statistical Analysis of the Change in Responses to Statement 6, “Teachers explain Open-ended questions very well.”*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
TI-N (E1 + E3)	81	<u>-0.15</u>	0.81	.09
Inv (E1 + E2)	68	<u>-0.21</u>	0.70	<b>.02</b>
E1(E1)	44	<u>-0.34</u>	0.68	<b>&lt;0.0001</b>

Responses to the statement, “I can read but do not understand Open-ended questions” showed a statistically significant change in scores for students in the Intervention (E1 + E2) and Experimental (E1 + E2 + E3) groups. There was weak evidence of a change in attitude for the students in Grp3 (E2 + E3 + C) (see Table 4.8). The Responses from the TI-84 (E2 + C) group showed weak, non-significant evidence of a change in attitude.

These responses showed that many of the students felt less confident about their understanding of Open-ended questions at the end of the study than they did at the beginning of the study. The negative wording on the question may have confused some students or the responses may indicate that the students learned they did not understand Open-ended questions as well as they thought they did at the start of the study.

Table 4.8

*Results of Statistical Analysis of the Change in Responses to Statement 4, “I can read but do not understand Open-ended questions”*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
TI-84 ( E + C)	54	0.20	0.83	.08
Inv (E1 + E2)	69	0.24	0.89	<b>.03</b>
Exp (E1 + E2 + E3)	104	0.20	0.83	<b>.02</b>
Grp3 (E2 + E3 + C)	89	0.17	0.77	<b>.04</b>

Table 4.9 shows that the scores of the Control group (C) students responses to the statement, “I usually understand the text or story in Open-ended questions” showed a statistically significant, negative change in attitude and the scores of students in the TI-84 (E2 + C) group showed a non-significant negative change in attitude. The significant, negative change in their responses from the students in the Control group may have influenced the results of the larger TI-84 (E2 + C) group.

Table 4.9

*Results of Statistical Analysis of the Change in Responses to Statement 7, “I usually understand the text or story in Open-ended questions.”*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
TI-84 (E2 + C)	53	<u>-0.25</u>	0.94	.06
C (C)	29	<u>-0.45</u>	1.02	<b>.03</b>

*Category 2-Percents (Statement 10)*

The percent statement, “I am good at working with percents” recorded a statistically significant change in responses from students in the Traditional (E3 + C) and Grp3 (E2 + E3 + C) groups (see Table 4.10). The Intervention Curriculum did not focus on percents. Percents were used to calculate the sectors of circle graphs, but the computation was not emphasized. The Traditional Curriculum may have placed more emphasis on finding percents than the Intervention Curriculum did. The other cohorts did not show a significant change in attitude, before to after, the unit of instruction.

Table 4.10

*Results of Statistical Analysis of the Change in Responses to Statement 10, “I am good at working with percents.”*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
Trad (E3 + C)	67	0.21	0.73	<b>.02</b>
Grp3 (E2 + E3 + C)	91	0.19	0.74	<b>.02</b>

*Category 3- Interpreting Statistics (Statements 11, 12, 15, 16, 29, 30, 32)*

The third group of statements dealt with drawing conclusions from various types of data (see Table 4.11). Statements in this category asked about interpreting graphs and tables, deciding whether data was biased or unbiased, and evaluating arguments based on given data.

Students in the Intervention (E1 + E2) and Experimental (E1 + E2 + E3) groups showed a statistically significant change their response scores in this content area. The change in responses by students in the TI-Nspire (E1 + E3) and TI-Nspire Intervention (E1) groups were non-significant but suggested weak evidence of a possible change in attitude (see Table 4.11). The changes for students using the Intervention Curriculum may have been because students spent a lot of time analyzing graphs and drawing conclusions about the data. However, in the TI-Nspire groups, the lack of proficiency using the calculator appears to have affected students' feelings about their ability to analyze data. As previously mentioned, the students apparently were concentrating on what buttons to push and not what was happening with the data analysis.

The results of analyzing the change in responses to the individual statements in the category of Interpreting Statistics resulted in statistically significant, positive changes from students in the TI-84 (E2 + C) and Intervention (E1 + E2) groups in response to the statement, "I am good at interpreting tables" (see Table 4.12). The responses in Grp3 (E2 + E3 + C) showed a weak, non-significant change in attitude. As mentioned previously, the Intervention Curriculum focused on the interpretation of tables and scatter plots using the same data while the Traditional Curriculum analyzed many different sets of data. This

may have contributed to the statistically significant change in responses from students in the Intervention group regarding their level of comfort with using tables. In contrast, students from groups using the Traditional Curriculum group appeared to have had less of a change in attitude on this topic than the students from Intervention group.

Table 4.11

*Results of Statistical Analysis of the Change in Responses to Statements Related to Analyzing Data and Drawing Conclusions from Data.*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
TI-N (E1 + E2)	82	0.09	.44	.06
Inv (E1 + E3)	69	0.11	.34	<b>.01</b>
Exp (E1 + E2 + E3)	106	0.10	.42	<b>.01</b>
E1(E1)	45	0.09	.33	.07

Table 4.12

*Results of Statistical Analysis of the Change in Responses to Statement 12, “I am good at interpreting tables.”*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
TI-84 (E2 + C)	53	.30	.82	<b>.01</b>
Inv (E1 + E2)	69	0.23	0.75	<b>.01</b>
Grp3 (E2 + E3 + C)	90	0.14	0.82	.09

Table 4.13

*Results of Statistical Analysis of the Change in Responses to Statement 29, “I am good at deciding if a sample is biased or unbiased.”*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
TI-N (E1 + E3)	77	0.37	0.94	<b>&lt;0.0001</b>
Inv (E1 + E2)	63	0.30	0.99	<b>.02</b>
Exp (E1 + E2 + E3)	99	0.34	0.93	<b>&lt;0.0001</b>
Grp3 (E2 + E3 + C)	87	0.18	0.82	.05
E1(E1)	41	0.34	1.06	.05

Responses to the statement, “I am good at deciding if a sample is biased or unbiased” exhibited significant or weak, non-significant positive changes by all groups except the Traditional (E3 + C), TI-84 (E2 + C) and Control (C) groups (see Table 4.13). Spending time studying data sets in-depth seems to have increased student perception of their understanding of biased and unbiased data. The Experimental (E1 + E2 + E3) and TI-Nspire (E1 + E3) group had strongly significant changes in attitude and the students in the Intervention curriculum group exhibited a significant, positive change on this topic. Grp3 (E2 + E3 + C) and the Intervention TI-Nspire (E1) group recorded weak evidence of a possible change in attitude.

The students in the TI-Nspire (E1 + E3) and TI-Nspire Intervention (E1)) (see Table 4-14), exhibited weak, non-significant changes in their responses to the statement, “I am good at evaluating arguments based on an analysis of data” while the responses from the Intervention (E1 + E2) group exhibited weak evidence of a change. The students using the Intervention Curriculum spent considerable time analyzing data and drawing

conclusions about the data sets. Thus it was expected that their attitude about their ability in this area would improve. All the study groups are represented in one of the cohorts that exhibited change, so it appears that most students had at least a weak change in attitude.

*Category 4- Creating Graphs (Statements 13, 17-19, 24- 28, 31)*

Category 4 had statements about creating graphs and modeling situations (see Table 4.15).

Table 4.14

*Results of Statistical Analysis of the Change in Responses to Statement 32, “I am good at evaluating arguments based on an analysis of data.”*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
TI-N (E1 + E3)	78	0.17	0.80	.07
Inv (E1 + E2)	65	0.18	0.75	.05
Exp (E1 + E2 + E3)	102	0.17	0.81	<b>.04</b>
E1(E1)	41	0.20	0.68	.07

Six of the study groupings had strongly significant positive changes in their responses to questions in this category. The two groups, which did not have significant changes in attitude, were the Control (C) and TI-84 (E2 + C) groups (see Table 4.15). The change in the responses for students using the Intervention Curriculum and/or the TI-Nspire may have been due to the emphasis on creating graphs in that curriculum, the fact that the data was already in the TI-Nspire, and/or the ease of creating graphs on the TI-Nspire. The graphing features on the TI-84 are less extensive than those on the TI-Nspire.



The students using the TI-84 had to input the data before they could create scatter plots. Creating graphs was more complicated and time consuming for students using the TI-84 than it was for those using the TI-Nspire. Students using the TI-84 had to draw circle graphs by hand.

Table 4.15

*Results of Statistical Analysis of the Change in Responses to Statements about Drawing Graphs and Modeling Situations*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
TI-N (E1 + E3)	82	0.27	0.46	<b>&lt;0.0001</b>
Trad (E3 + C)	67	0.18	0.51	<b>&lt;0.0001</b>
Inv (E1 + E2)	69	0.18	0.36	<b>&lt;0.0001</b>
Exp (E1 + E2 + E3)	106	0.24	0.44	<b>&lt;0.0001</b>
Grp3 (E2 + E3 + C)	91	0.17	0.47	<b>&lt;0.0001</b>
E1(E1)	45	0.20	0.37	<b>&lt;0.0001</b>

Students in all eight of the groups showed a statistically significant change in attitude in response to the statement, “I am good at finding outliers” (see Table 4.16). This may have been because the students were not familiar with the term “outlier” prior to the study. Once they realized what an outlier is, they had no trouble identifying them.

The statement, “I am good at drawing histograms” (see Table 4.17) produced strongly significant changes in responses from students in the Intervention (E1 + E2), Traditional (E3 + C), Experimental (E1 + E2 + E3), Grp3 (E2 + E3 + C), TI-Nspire

Intervention (E1) and TI-Nspire (E1 + E3) groups.

Table 4.16

*Results of Statistical Analysis of the Change in Responses to Statement 19, “I am good at finding outliers.”*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
TI-84 (E2 + C)	52	0.47	0.96	<b>&lt;0.0001</b>
TI-N (E1 + E3)	78	0.98	0.91	<b>&lt;0.0001</b>
Trad (E3 + C)	65	0.77	1.0	<b>&lt;0.0001</b>
Inv (E1 + E2)	65	0.78	0.92	<b>&lt;0.0001</b>
Control (C)	28	0.39	0.96	<b>.04</b>
Exp (E1 + E2 + E3)	102	0.88	0.93	<b>&lt;0.0001</b>
Grp3 (E2 + E3 + C)	89	0.71	0.99	<b>&lt;0.0001</b>
E1 (E1)	41	0.91	0.88	<b>&lt;0.0001</b>

The Control group (C) showed a weak, non-significant decrease in their responses to this statement. Responses from the TI-84 (E2 + C) group were not significant, but the change was negative. It appears as though the responses from the Control group may have influenced this negative change.

Responses to the individual statement, “I am good at making scatter plots” (see Table 4.18) showed a statistically significant change in attitude by student in the Intervention (E1 + E2), TI-Nspire (E1 + E3) and Experimental (E1 + E2 + E3) and Intervention TI-Nspire (E1) groups. Grp3 (E2 + E3 + C) exhibited weak evidence of a

possible change in attitude.

Table 4.17

*Results of Statistical Analysis of the Change in Responses to Statement 24, "I am good at drawing histograms."*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
TI-N (E1 + E3)	81	0.59	.92	<b>&lt;0.0001</b>
Trad (E3 + C)	66	0.30	.96	<b>.01</b>
Inv (E1 + E2)	68	0.18	.92	<b>&lt;0.0001</b>
C (C)	29	<u>-.28</u>	.75	.06
Exp (E1 + E2 + E3)	105	0.48	.92	<b>&lt;0.0001</b>
Grp3 (E2 + E3 + C)	90	0.24	.93	<b>.01</b>
E1(E1)	44	0.45	.95	<b>&lt;0.0001</b>

The students in the Traditional (E3 + C) group showed a weak, non-significant change in attitude. These results (see Table 4.18) are not surprising because of the amount of time spent working with scatter plots in both curricula. One possible reason for the lack in attitude change for the TI-84 and Control groups was the apparent difficulty students had creating some graphs on the TI-84 calculator and drawing others by hand.

Table 4.18

*Results of Statistical Analysis of the Change in Responses to Statement 18, “I am good at making scatter plots.”*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>P</i>
TI-N (E1 + E3)	81	0.33	0.82	<b>&lt;0.0001</b>
Trad (E3 + C)	66	0.21	0.98	.09
Inv (E1 + E2)	68	0.24	0.69	<b>.01</b>
Exp (E1 + E2 + E3)	104	0.28	0.79	<b>&lt;0.0001</b>
Grp3 (E2 + E3 + C)	89	0.18	0.91	.06
E1(E1)	45	0.31	0.70	<b>&lt;0.0001</b>

Table 4.19

*Results of Statistical Analysis of the Change in Responses to Statement 25, “I am good at drawing scatter plots.”*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
TI-N (E1 + E3)	82	0.50	0.96	<b>&lt;0.0001</b>
Trad (E3 + C)	67	0.28	1.00	<b>.02</b>
Inv (E1 + E2)	69	0.41	0.90	<b>&lt;0.0001</b>
Exp (E1 + E2 + E3)	106	0.43	0.93	<b>&lt;0.0001</b>
Grp3 (E2 + E3 + C)	91	0.26	0.94	<b>.01</b>
E1 (E1)	45	0.51	0.94	<b>&lt;0.0001</b>

Students in every group except the Control (C) and TI-84 (E2 + C) groups showed evidence of a statistically significant positive change in their responses to the statement, “I am good at drawing scatter plots” (see Table 4.19). It was interesting that students in the Traditional Curriculum (E3 + C) group and Grp3 (E2 + E3 + C) had significant changes in their responses to ‘drawing scatter plots’ (see Table 4.17) while a weak, non-significant change to ‘making scatter plots’. Maybe the students considered finding the data part of ‘making’ a scatter plot but not ‘drawing’ one (see the discussion related to Table 4.16). They may have considered ‘drawing’ to be creating the scatter plot by hand while ‘making’ was either creating it by hand or using the calculator. During the student interviews, every study group mentioned concern about using technology to draw graphs instead of drawing them by hand. The students enjoyed the convenience of using the calculator, but were afraid that they would not be proficient at creating graphs by hand. The interviews did not specifically shed light on the difference in student perception of ‘making’ versus ‘drawing’ a graph.

Table 4.20

*Results of Statistical Analysis of the Change in Responses to Statement 26, “I am good at drawing bar graphs.”*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
Inv (E1 + E2)	67	<u>-0.12</u>	0.54	.07
E1 (E1)	43	<u>-0.16</u>	0.43	<b>.02</b>

A negative, statistically significant change in attitude was recorded by students in the TI-Nspire Intervention Unit (E1) group in response to the statement, “I am good at drawing bar graphs.” Student responses in the Intervention Curriculum (E1 + E2) group (see Table 4.20) reported a weak, non-significant negative change in attitude. The Intervention Curriculum included answering statements about bar graphs, however, the students in the Intervention TI-Nspire part of this group used the calculator to create the graphs. Perhaps the distinction between ‘drawing’ and ‘making’ mentioned before affected the results for this statement.

Responses to the statement, “I am good at drawing circle graphs” showed a statistically significant negative change in attitude among students in the Intervention Curriculum (E1 + E2) group and a strongly significant, negative change in response from the TI-Nspire Intervention Curriculum (E1) group (see Table 4.21).

Table 4.21

*Results of Statistical Analysis of the Change in Responses to Statement 27, “I am good at drawing circle graphs.”*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
Inv (E1 + E2)	68	<u>-0.19</u>	0.60	<b>.01</b>
E1(E1)	44	<u>-0.27</u>	0.5440	<b>&lt;0.0001</b>

The students in group E1 and about half the students in the Traditional Curriculum group used the TI-Nspire to draw the circle graphs. These students did not have practice drawing circle graphs by hand. Perhaps this influenced student responses to

this statement. As mentioned in the discussion related to scatter plots, student interviews indicated concern about using technology to draw graphs, rather than drawing them by hand.

The Control (C) group was the only group that showed no significant change in attitude when responding to the statement, “I am good at selecting an appropriate measure of central tendency to best describe data.” Students in all the other groups showed a statistically significant or weak, non-significant change in their responses (see Table 4.22). The students interviewed felt confident with the concepts of mean, median and mode. Although most students had encountered these terms in their previous studies, perhaps they did not fully understand measures of central tendency prior to the unit of study.

Table 4.22

*Results of Statistical Analysis of the Change in Responses to Statement 31, “I am good at selecting an appropriate measure of central tendency to best describe data.”*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
TI-84 (E2 + C)	52	0.23	0.90	.07
TI-N (E1 + E3)	80	0.31	0.77	<b>&lt;0.0001</b>
Trad (E3 + C)	65	0.20	0.85	.06
Inv (E1 + E2)	67	0.36	0.79	<b>&lt;0.0001</b>
Exp (E1 + E2 + E3)	103	0.33	0.79	<b>&lt;0.0001</b>
Grp3 (E2 + E3 + C)	88	0.25	0.86	<b>.01</b>
E1(E1)	44	0.34	0.74	<b>&lt;0.0001</b>

*Category 5-Basic Statistics (Statements 20-23)*

Category 5 had questions about the mean, median, mode and range (see Table 4.23).

Table 4.23

*Results of Statistical Analysis of the Change in Responses to Statements about Basic Statistical Concepts.*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
Trad (E3 + C)	67	0.17	.68	<b>.05</b>

Most of the students indicated in the interviews that they were proficient with basic statistical concepts at the beginning of the unit of instruction. However, there was one group, the Traditional Curriculum (E3 + C) group, which recorded a weak, significant change in their responses to statements in this category. On the individual statements in this category, there were a few statistically significant or weak, non-significant changes in attitude.

The responses of the students in the Traditional (E3 + C) group showed a weak, non-significant change in attitude to the statement, “I am good at finding the mean of a set of data” (see Table 4.24). The fact that the other groups of students did not have a statistical change in attitude probably reflects the fact that the students were confident with this material at the beginning of the unit of instruction.



Table 4.24

*Results of Statistical Analysis of the Change in Responses to the Statement 20, “I am good at finding the mean of a set of data.”*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
Trad (E3 + C)	67	0.16	0.73	.07

Table 4.25

*Results of Statistical Analysis of the Change in Responses to the Statement 22, “I am good at finding the mode of a set of data.”*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
Trad (E3 + C)	67	0.21	0.80	<b>.03</b>
Grp3 (E2 + E3 + C)	91	.16	.81	.06

A statistically significant change in attitude was recorded for the students using the Traditional Curriculum (E3 + C) in response to, “I am good at finding the mode of a set of data.” Grp3 (E2 + E3 + C) exhibited weak, statistically non-significant evidence of a change in attitude for the same statement (see Table 4.25). The Intervention Curriculum did not focus on the mode, only the mean and median. This may account for no statistically significant change in student attitudes about the mode. In the interviews, the students indicated that they were confident with this concept before the unit of instruction. The Traditional Curriculum of instruction may have spent more time on mode. Perhaps this affected the attitudes of the students in these groups.

Table 4.26

*Results of Statistical Analysis of the Change in Responses to Statement 21, “I am good at finding the median of a set of data.”*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
TI-N (E1 + E3)	82	0.13	0.60	<b>.05</b>

The change in the student responses to the statement, “I am good at finding the median of a set of data” was statistically significant for the TI-Nspire (E1 + E3) group (see Table 4.26). The interviews confirmed that most of the students were confident about mean, median and mode before the unit of study so little change in student responses was expected.

#### *Category 6-Interpreting Graphs (Statements 34-40)*

The last category of statements dealt with interpreting and predicting from graphs (see Table 4.27). This is a very important topic in terms of student performance on the HSPA. Prior to the unit of instruction many of the student responses indicated that given some data they could compute some basic data statistics, but did not fully understand how to use them in statistical analysis of actual problems.

For this category there was a strongly significant change in attitude for students in all groups except the TI-84 (E2 + C) and Control (C) groups (see Table 4.27). Although the curriculum (Intervention Curriculum or Traditional Curriculum) used did not seem influence this change in student attitude, the type of calculator (TI-Nspire or TI-84) used did. The discussion of the next statement shows that most of the same study groups also

reported a strongly significant change the students' perception of their ability to interpret and predict from specific types of graphs.

Table 4.27

*Results of the Statistical Analysis of the Change in Responses to Statements about Interpreting and Predicting from Graphs.*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
TI-N (E1 + E3)	81	0.26	.46	<b>&lt;0.0001</b>
Trad (E3 + C)	67	0.20	.52	<b>&lt;0.0001</b>
Inv (E1 + E2)	68	0.18	.49	<b>&lt;0.0001</b>
Exp (E1 + E2 + E3)	105	0.22	.49	<b>&lt;0.0001</b>
Grp3 (E2 + E3 + C)	91	0.18	.54	<b>&lt;0.0001</b>
E1(E1)	44	0.23	.42	<b>&lt;0.0001</b>

The students in the Control (C) and the TI-84 (E2 + C) groups reported no statistically significant change in their responses to the statement, "I am good at interpreting histograms" (see Table 4.28). Students in all of the other groups recorded strongly significant positive changes in attitude. Consistent with student responses for this category as a whole, student responses to this statement indicate that the student's curriculum group did not seem to make a difference but the calculator used did.

Table 4.28

*Results of Statistical Analysis of the Change in Responses to Statement 34, “I am good at interpreting histograms.”*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>P</i>
TI-N (E1 + E3)	80	0.60	0.81	<b>&lt;0.0001</b>
Trad (E3 + C)	64	0.34	0.88	<b>&lt;0.0001</b>
Inv (E1 + E2)	68	0.41	0.89	<b>&lt;0.0001</b>
Exp (E1 + E2 + E3)	104	0.51	0.86	<b>&lt;0.0001</b>
Grp3 (E2 + E3 + C)	88	0.31	0.90	<b>&lt;0.0001</b>
E1(E1)	44	0.52	0.82	<b>&lt;0.0001</b>

Student responses to “I am good at interpreting scatter plots” recorded statistically significant or weak, non-significant change in attitude for all of the study groups (see Table 4.29). This reflects the emphasis placed on scatter plots in both units of instruction. Students in the TI-Nspire, Experimental and Intervention Ti-Nspire groups all exhibited strongly significant changes in attitude. The students taught using the Intervention Curriculum exhibited statistically significant changes in attitudinal responses to the statement, “I am good at drawing a line of best fit” (see Table 4.30). The Traditional Curriculum (E3 + C) students showed a weak, non-significant change in attitude. Students using the Intervention Curriculum (E1 + E2) spent a lot of time computing and working with lines of best fit. Finding and graphing a line of best fit with the TI-Nspire was considerably easier than it was with the TI-84. This may account for the strongly

Table 4.29

*Results of Statistical Analysis of the Change in Responses to Statement 35, “I am good at interpreting scatter plots.”*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>P</i>
TI-84 (E2 + C)	54	0.31	0.91	<b>.01</b>
TI-N (E1 + E3)	81	0.47	0.98	<b>&lt;0.0001</b>
Trad (E3 + C)	67	0.52	0.93	<b>&lt;0.0001</b>
Inv (E1 + E2)	68	0.29	0.96	<b>.01</b>
C (C)	30	0.33	0.84	<b>.04</b>
Exp (E1 + E2 + E3)	105	0.43	0.98	<b>&lt;0.0001</b>
Grp3 (E2 + E3 + C)	91	0.46	0.95	<b>&lt;0.0001</b>
E1(E1)	44	0.30	0.95	<b>.05</b>

Table 4.30

*Results of Statistical Analysis of the Change in Responses to Statement 39, “I am good at drawing a line of best fit.”*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>P</i>
TI-N (E1 + E3)	81	0.35	0.84	<b>&lt;0.0001</b>
Trad (E3 + C)	65	0.18	0.86	<b>.09</b>
Inv (E1 + E2)	68	0.26	0.94	<b>.02</b>
Exp (E1 + E2 + E3)	105	0.27	0.89	<b>&lt;0.0001</b>
E1 (E1)	44	0.41	0.87	<b>&lt;0.0001</b>

significant change reported by many of the students.

The curriculum used did not seem to be an influential factor in attitude change when students responded to the statement, “I am good at predicting from a line of best fit” (see Table 4.31). Responses by students in the TI-Nspire (E1 + E3), Experimental (E1 + E2 + E3) and TI-Nspire Intervention (E1) exhibited strongly significant changes in attitude. Students in the Intervention (E1 + E2) group recorded significant changes in attitude. Ease of inserting a line of best fit into a scatter plot on the TI-Nspire appears to have allowed the students to focus on predicting, rather than on graphing the line.

Table 4.31

*Results of Statistical Analysis of the Change in Responses to Statement 40, “I am good at predicting from a line of best fit.”*

Source	<i>N</i>	<i>M</i>	<i>SD</i>	<i>p</i>
TI-N (E1 + E3)	81	0.33	0.88	<b>&lt;0.0001</b>
Inv (E1 + E2)	68	0.31	0.93	<b>.01</b>
Exp (E1 + E2 + E3)	105	0.26	0.88	<b>&lt;0.0001</b>
E1 (E1)	44	0.45	0.95	<b>&lt;0.0001</b>

#### Summary of Quantitative Findings for the Attitudinal Survey

This section is a discussion of the findings from the attitudinal survey, summarized by groups. Tables 4.33 and 4.34 are a compilation of statistically significant results from the attitudinal survey (Table 4.32 explains the codes used in these tables). Table 4.32 is a summary of the change in overall attitudinal changes and Categorical

Attitudinal changes. Table 4.34 summarizes the change in attitude on the individual statements discussed in the previous section of this chapter.

Table 4.32

*Codes for Changes in Study Group Responses on the Attitudinal Survey*

Code	Meaning
+HSig	Positive, strongly statistically significant ( $p < 0.01$ )
+ Sig	Positive and statistically significant ( $0.01 \leq p < (0.05)$ )
+WSig	Positive and statistically weak, non-significant ( $0.05 \leq p < 0.10$ )
-HSig	Negative and strongly statistically significant ( $p < 0.01$ )
-Sig	Negative and statistically significant ( $0.01 \leq p < (0.05)$ )
-WSig	Negative and statistically weak, non-significant ( $0.05 \leq p < 0.10$ )

*Calculator – TI-84 (E2 + C) and TI-Nspire (E1 + E3)*

The students using the TI-Nspire (E1 + E3) recorded a statistically significant positive change in their overall attitudes. They recorded positive and strongly statistically significant change in their responses to ten of the statements, significant change to one statement, weak, non-significant positive changes to one statement and a weak, non-significant negative response to one (see tables 4.33 and 4.34)

Statistically significant positive change in the assessment of their ability to interpret statistics and graphs, draw a line of best fit and then predict from that line were recorded. The ease of drawing a line of best fit with the TI-Nspire along with having the data already in the handheld appears to have influenced these changes in student attitudes. Students in these same study groups also reported positive changes in their

attitude about their ability to create graphs, specifically histograms and scatter plots.

Table 4. 33

*Summary of Results of Statistical Analysis on the Change in Responses on the Attitudinal Survey (Total Survey and Category Changes)*

Source	Study Group							
	TI-84	TI-N	Trad	Inv	C	Exp	Grp3	E1
Total		+HSig	+HSig	+HSig		+HSig	+HSig	+HSig
Survey Category								
1				+Sig		+Sig		
2			+WSig				+WSig	
3		+WSig		+Sig		+Sig		+WSig
4		+HSig	+HSig	+HSig		+HSig	+HSig	+HSig
5			+Sig					
6		+HSig	+HSig	+HSig		+HSig	+HSig	+HSig

Students in the TI-Nspire (E1 + E3) group recorded a weak, non-significant negative change in attitude about teachers explaining Open-ended questions well. This may have been related to the findings reported earlier about student-centered learning versus teacher- centered learning. The unfamiliar approach used in the Intervention Curriculum may have contributed to the students' negative attitude changes.

Students in the TI-84 (E2 + C) group showed no change in attitude towards any category of statements any category but did show positive changes to five statements (one strongly significant (finding outliers), two significant (interpreting tables and scatter plots) and two weak, non-significant (I can read but do not understand open ended questions and interpreting tables) (see Tables 4.33 and 4.34).



Table 4. 34

*Summary of Results of Statistical Analysis on the Change in Responses on the Individual Questions on Attitudinal Survey (Significant and Weak, Non-significant Responses)*

Source	TI-84	TI-N	Trad	Inv	C	Exp	Grp3	E1
Question	Study Group							
Category 1 (Open-ended # 1-9)								
4	+WSig			+Sig		+Sig	+Sig	
6		-WSig		-Sig				-HSig
7	-WSig				-Sig			
Category 2 (Percents # 10)								
10			+Sig				+Sig	
Category 3 (Interpreting Statistics 11, 12, 15, 16, 29, 30, 32)								
11								
12	+Sig			+Sig			+WSig	
29		+HSig		+Sig		+HSig	+Sig	+Sig
32		+WSig		+WSig		+Sig	+WSig	+WSig
Category 4 (Creating Graphs 13, 17-19, 24-28, 31)								
19	+HSig	+HSig	+HSig	+HSig	+Sig	+HSig	+HSig	+HSig
24		+HSig	+Sig	+HSig	-WSig	+HSig	+Sig	+HSig
18		+HSig	+WSig	+HSig		+HSig	+WSig	+HSig
25		+HSig	+Sig	+HSig		+HSig	+HSig	+HSig
26				-WSig				-Sig
27				-Sig				-HSig
31	+WSig	+HSig	+WSig	+HSig		+HSig	+HSig	+HSig
Category 5 (Basic Statistics 20-23)								
20			+WSig					
22			+Sig				+WSig	
21		+Sig						
Category 6 (Interpreting Graphs 34 – 40)								
34		+HSig	+HSig	+HSig		+HSig	+HSig	+HSig
35	+Sig	+HSig	+HSig	+Sig	+Sig	+HSig	+HSig	+Sig
39		+HSig	+WSig	+Sig		+HSig		+HSig
40		+HSig		+HSig		+HSig		+HSig

Students in the TI-84 (E2 + C) group recorded a statistically weak, non-significant negative change in attitude towards understanding Open-ended questions. Perhaps some of the students realized that they were not as good at Open-ended questions as they thought they were before they started the study unit.

Students, in every group, reported more positive attitudes about their ability to interpret scatter plots and find outliers. The use of calculators, by students in all study groups, to calculate and display both the equation and the graph of the line of best fit provided more time for students to focus on interpreting the graphs. Using the TI-Nspire had a more positive influence on student attitudes than using the TI-84.

*Curriculum-Intervention Curriculum (E1 + E2) and Traditional Curriculum (E3 + C)*

When comparing the attitudinal changes of the students in the Traditional Curriculum (E3 + C) group with the students in the Intervention Curriculum (E1 + E2) group, the responses indicated that students in both groups recorded positive changes in many of the same areas. (The students (that is, all study participants) recorded positive changes in their total change in attitude and four categories of statements. The Traditional Curriculum (E3 + C) group recorded positive changes in attitude towards eleven individual statements while the Intervention Curriculum (E1 + E2) recorded thirteen positive changes and three negative changes) (see Tables 4.33 and 4.34). The areas where both groups had positive changes included drawing various types of graphs, interpreting scatter plots and histograms and deciding on an appropriate measure of central tendency to best describe sets of data. The students using the Intervention Curriculum (E1 + E2) also recorded positive attitudinal changes about finding, and then predicting from, a line

of best fit.

One statement in which the students in the Intervention Curriculum ( $E1 + E2$ ) group recorded a negative change in attitude was the statement about teachers explaining questions well. As mentioned earlier, the Intervention Curriculum of instruction was designed to make the students do a lot of the work on their own, without a lot of teacher explanation. The other statement for which this group had a negative change concerned drawing circle graphs. Some of the students in this group used the TI-Nspire and did not draw circle graphs by hand. Most of the interviewed students, in all groups, seemed comfortable with drawing circle graphs.

The instructional unit of study did not appear to have as much affect on student attitude as did the type of calculator used.

*Groups - Experimental ( $E1 + E2 + E3$ ) and Control (C)*

The students in the Control (C) group recorded little statistically significant change in attitude when singled out from all the other groups (see Tables 4.33 and 4.34). There were only two statements on the attitudinal survey where these students recorded statistically significant positive changes in attitude, specifically Statement 19, “I am good at finding outliers” and Statement 35, “I am good at interpreting scatter plots.” The Control (C) group students recorded a statistically significant negative change in attitude when it came to the understanding of the text or story in Open-ended questions.

The students in the Experimental ( $E1 + E2 + E3$ ) group had a positive change in attitude change in four categories of statements and twelve individual statements (see Tables 4.33 and 4.34). While these students recorded statistically significant positive

changes in their attitudes about drawing histograms, the Control (C) group students recorded weak, non-significant negative changes in attitude. Students in the Experimental (E1 + E2 + E3) group recorded statistically significant positive changes in attitudes about the following categories of statements; Open-ended questions, interpreting statistics, and creating and interpreting graphs. On the individual statements, the students in the Experimental group showed a significant change to most statements in each of the categories in which they had positive changes (see Table 4.32). As mentioned in the Curriculum-Intervention (E1 + E2) and Traditional (E3 + C) section, using the TI-Nspire seemed to be the main factor in attitude changes.

*Grp3 (E2 + E3 + C) and Intervention + TI-Nspire (E1)*

Students in the both of these groups recorded positive changes in their total change in attitude and in three categories of statements for each group (see Tables 4.33 and 4.34). Both groups of students recorded statistically significant changes in their attitudes about creating graphs, interpreting graphs and in their overall change in attitudinal scores. Students in both groups recorded statistically significant attitudinal changes about drawing and interpreting scatter plots and histograms.

The students in the TI-Nspire Intervention (E1) group recorded some statistically significant negative changes in attitude when it came to drawing bar graphs, circle graphs and teachers explaining Open-ended questions well (see Table 4.34). This may be because all of the graphs were drawn on the TI-Nspire for group E1, rather than by hand. Students in the TI-84 group drew the circle graphs by hand and used the calculator to draw the bar graphs. Using the technology instead of doing everything by hand may have

affected the students' negative change in attitude.

*Answer to the Research Statement, "Did using problem/project-based learning have an effect on students' attitude towards mathematics and data analysis?"*

The students using the Intervention Curriculum (E1 + E2) had a statistically significant positive change in their attitudes on thirteen of the statements discussed in this chapter. The students using the Traditional Curriculum (E3 + C) also reported a statistically significant positive change in attitude on eleven of the statements discussed (see Table 4.34). The positive changes for students in both groups were recorded in statements about drawing various types of graphs, interpreting scatter plots and histograms, and deciding on an appropriate measure of central tendency to best describe data. The Intervention Curriculum (E1 + E2) students also reported statistically significant positive attitude change about finding and predicting from the line of best fit.

Problem/project-based learning in mathematics was new to our students. The students were used to teacher-centered instruction and were reluctant to try a student-centered approach. They were out of their comfort zone, which may have affected their acceptance of the unit of instruction.

The students in the Intervention Curriculum (E1 + E2) found some of the material to be too repetitive. That is, repeatedly analyzing the same data set in different ways appears to have diminished their interest in what was being studied. Although most agreed that by the end of the study they were very comfortable with comparing different sets of data. In contrast, the students in the Traditional Curriculum (E3 + C) group liked having the variety of data and problems but the students indicated that they would have

enjoyed some in-depth analysis using the same data.

Using the same data sets for multiple purposes appears to have both advantages and disadvantages. The students in this study appeared to lack the ability, and interest in, critically comparing and contrasting various sets of data. In Chapter 6 I will make some recommendations that address this issue.

Despite their lack of proficiency with the TI-Nspire, the calculator seemed to have had a greater positive impact on student attitude than the unit of instruction. A lack of experience with student-centered units of instruction may have been a contributing factor for the diminished impact of the Intervention Curriculum. As the teachers mentioned in their interviews, in our school environment the Intervention Curriculum may have been more successful if used with older students.

## CHAPTER 5: QUANTITATIVE RESULTS

This chapter discusses the findings of the quantitative analysis portion of the study relating to the first three research statements, restated here for convenient reference.

1. What is the effect of a problem/project-based instructional unit on ninth grade basic skills mathematics students' understanding of how to represent, interpret and analyze real world data as measured by their performance on questions similar those in the Data Analysis Cluster of the NJ HSPA?
2. What is the effect of using the document features of the TI-Nspire in a data analysis unit on the students' mastery of related tools and concepts?
3. What is the effect of the combination of the document features of the TI-Nspire handheld and the problem/project-based unit of instruction on the students' mastery of related tools and concepts?

### Study Design and Variables

As described in Chapter 3, the study was a two factor design (Instruction [INSTR] and Calculator[CALC]) with four independent study groups. This can be schematically represented as follows:

Source	Calculator (CALC)	
Instruction (INSTR)	TI-Nspire	TI-84
<b>Intervention Instructional Unit</b>	Group E1	Group E2
Number (classes, students)	(4,45)	(3,24)
Teacher	B and C	A
<b>Traditional Instructional Unit</b>	Group E3	Group (C)
Number (classes, students)	(3,41)	(3, 32)
Teacher	B	A

### Figure 5.1 Structure of Study Groups

Evaluation of each study group's (cohort) understanding of data analysis concepts and procedures was performed using the Pre-test-Post-test instruments which are shown in Table 5.1

Table 5.1

#### *Pre-test and Post-test Instruments*

Multiple-choice	MC1 – MC10	MC = Mean (MC1 – MC10)
Open-ended	OE1 – OE3	OE = Mean (OE1 – OE3)
Total		Mean (MC + OE)

To address the research statements, several methods of analysis were employed to assess the effect of the factors INSTR and CALC from Pre-test to Post-test based on the instruments listed above.

The analysis also included the comparison of Pre-and Post-tests responses to individual questions. The Pre-test and Post-test were not designed as parallel tests, but as tests covering the concepts found on the New Jersey HSPA data analysis cluster. Some of the questions paired up nicely and others did not. Two teachers, in addition to me, looked at the questions and decided on the pairings. From those pairs of questions, the only comparisons included in this discussion are those for which there were statistically significant and those that showed weak, non-significant changes in a study groups' answers.

### Pre-test and Post-test Results

#### *Method of Analysis*



Summary statistics were computed for the Pre-test and Post-test results for the Multiple-choice (MC), Open-ended (OE) and Total (TOTAL = MC + OE) scores by INSTR, CALC and cohort. The Pre-test and Post-test scores were then separately evaluated using the analysis of variance (ANOVA) method based on the following General Linear Model (GLM):

$$\text{Equation 5.1: } Y = \text{INSTR} + \text{CALC} + \text{INSTR} * \text{CALC}$$

where  $Y = \text{MC, OE or TOTAL}$  and  $\text{INSTR} * \text{CALC}$  denotes the *interaction* effect. Note that a ‘significant’ interaction implies that the effect of CALC is **NOT** the same at each level of INSTR.

By convention, a ‘statistically significant’ result is when an effect has a  $P\text{-value} < 0.05$  from the statistical test employed. That is, regardless of the method of analysis, we may compare the P-value to the conventional  $\alpha = 0.05$  significance level to assess whether a result is significant (or not) relative to the *null* hypotheses. The P-value is tied to the null hypotheses of interest, denoted as  $H_0$ , where  $H_0$  represents the “status quo”, or equivalently, there is no effect due to a particular factor. For example, for the INSTR factor,  $H_0$  is: on average, there is no difference between the performance of students using the Traditional (Trad) and Intervention (Inv) methods of instruction. If the P-value is  $< 0.05$  we say that *at least two* of the group means differ so, for simplicity, we take the expression of the alternative hypothesis as  $H_1$ : “not  $H_0$ ” unless otherwise specified. The actual P-value provides a measure of the likelihood of obtaining our test result assuming  $H_0$  is true. By convention, we agree that a  $P\text{-value} < 0.05$  provides sufficient evidence against  $H_0$ . That is, we say we “reject  $H_0$ ”. It is important that while

“statistical significance” (or lack thereof) is determined with respect to  $\alpha = 0.05$ , the P-value provides a measure of “strength” of the significance. Thus, a P-value  $< 0.01$  is regarded as strong evidence against  $H_0$ , whereas  $0.05 \leq \text{P-value} < 0.10$  is not significant, but suggests there may be weak evidence against  $H_0$ . These qualifications can be useful when planning follow up research.

However, the concept of  $H_0$  is inferential in that we are implying this applies to ALL students (in the target population). Clearly, this study has not encompassed the entire target population so we use the P-value to assess the likelihood that  $H_0$  could be true. Specifically, the P-value represents the chance that we obtained our test result based on the sample observations given that  $H_0$  is true.

To account for the fact that each student was measured twice (Pre-test and Post-test) repeated measures ANOVA were also employed. This method evaluates both the Pre-test and Post-test results simultaneously with respect to a factor and, hence, accounts for the expected correlation between a student’s performance on these tests.

For a simple factor, for example INSTR, the univariate repeated measures ANOVA model has the form:

$$\text{Equation 5. 2: } Y_1 Y_2 = \text{INSTR} + \text{STUD}(\text{INSTR}) + \text{TIME} + \text{INSTR} * \text{TIME}$$

where  $Y_1$  and  $Y_2$  are the Pre-test and Post-test scores for MC, OE or TOTAL. TIME is simply a proxy variable for the fact that each student was measured twice, i.e. Time = 1 (Pre-test) or 2 (Post-test). The factor STUD (INSTR) represents the effect of randomly assigning a student to one of the INSTR methods, Traditional (TRAD) or Intervention (Inv). The effect of INSTR is assessed relative to the STUD(INSTR) factor and is

referred to as the “Between subjects” effect. It averages the Pre-test and Post-test results (i.e., ignores the TIME factor). That is, we are testing whether  $H_0$ : no difference in INSTR methods after averaging across TIME.

The effect of INSTR “Within” each testing period is accessed via the terms: TIME + TIME\*INSTR. This is the “Within subjects” effects which indicate whether there was an overall change from Pre-test to Post-test (TIME). In addition, it provides evidence of whether or not the change from Pre-test to Post-test was different for each level of INSTR i.e., the interaction effect TIME \* INSTR.

#### *Summary Statistics*

Presented first are the results of the data analysis that helped determine if the study group had an effect on student test scores. Table 5.2 presents the mean scores for the Multiple-choice questions and the Open-ended questions along with the change in scores from Pre- to Post-test for all of the study groups. Table 5.3 presents the same data for the Total test scores. Within each comparison group, Figure 5.2 presents some of that data graphically.

*Is there a difference between the four study groups?*

#### *GLM Procedure*

The results of applying the General Linear Modeling (GLM) Procedure (see Equation 5.1) separately to the Pre-test and Post-test scores are presented in Table 5.4.

Table 5.2

*Means of the Multiple-choice Questions and Open-ended Questions for all Groups and Cohorts*

Factor	Source	Multiple-choice			Open-ended		
		<i>N</i>	<i>Pre</i>	<i>Post</i>	<i>N</i>	<i>Pre</i>	<i>Post</i>
CALC	TI-84	52	3.73	4.33	56	0.63	2.90
	TI-N	81	3.85	5.22	86	2.07	4.92
INSTR	Inv	67	3.70	4.94	69	1.64	3.78
	Trad	66	3.91	4.8	73	1.37	4.44
E1	Inv TI-N	43	4.00	5.35	45	2.16	4.33
E2	Inv TI-84	24	3.17	4.21	24	0.67	2.75
E3	Trad TI-N	38	3.68	5.08	41	1.98	5.56
C	Trad TI-84	28	4.21	4.43	32	0.59	3.00

*Note: Because the structure of the Open-ended Pre-test and Post-test questions*

*(scores 0 – 3) was different from the Multiple-choice questions (scores from 0 – 1), we decided to use the full cohort of permissions available (142 instead of 133)*

Table 5.3

*Means of the Total scores for all Groups and Cohorts*

Factor	Source	<i>N</i>	<i>Pre</i>	<i>Post</i>
CALC	TI-84	52	4.41	7.4
	TI-N	81	6.05	10.25
INSTR	Inv	67	5.39	8.73
	Trad	66	5.42	9.55
E1	Inv TI-N	43	6.26	9.72
E2	Inv TI-84	24	3.83	6.96
E3	Trad TI-N	38	5.82	10.84
C	Trad TI-84	28	4.89	7.79

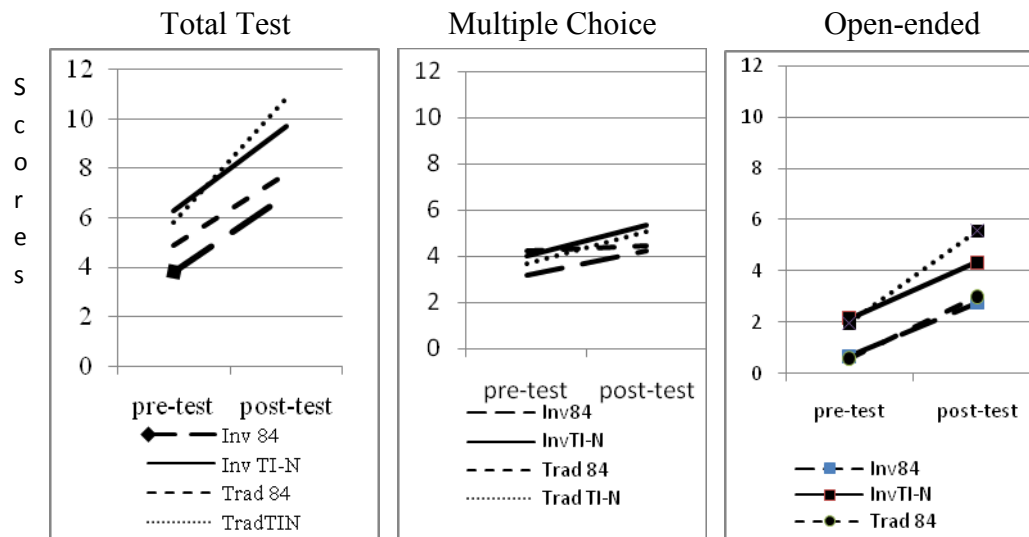


Figure 5.2 Graphs for the change in mean scores from Pre-test to Post-test for the Four independent study groups

Table 5.4

*Pre-test and Post-test GLM Procedure Results for the Interaction of Instruction and Calculator*

	Pre-test					Post-test			
Source	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>p</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Total Scores									
INSTR	1	3.02	3.02	0.43	0.51	29.91	29.91	3.1	0.08
Calc	1	88.15	88.15	12.4	<0.0001	266.72	266.72	27.63	<0.0001
INSTR*calc	1	17.71	17.71	2.5	0.12	0.68	0.68	0.07	0.79
Multiple-choice									
INSTR	1	4.22	4.22	1.63	0.20	0.02	0.02	0.01	0.93
Calc	1	0.72	0.72	0.28	0.60	25.26	25.26	9.07	<0.0001
INSTR*calc	1	14.64	14.64	5.65	0.02	1.89	1.89	0.68	0.41
Open-ended									
INSTR	1	0.53	0.53	0.17	0.68	18.27	18.27	2.81	0.09
Calc	1	68.95	68.95	22.44	<0.0001	143.69	143.69	22.07	<0.0001
INSTR*calc	1	.10	.10	.03	0.86	8	8	1.23	0.27

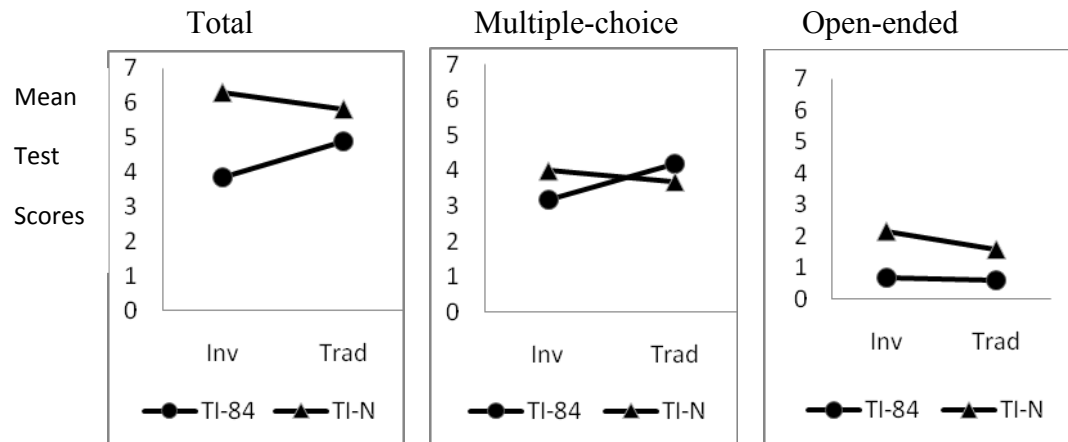


Figure 5. 3 Pre-test Interaction Plots for INSTR\*CALC

*Interaction Effect*

Since the GLM procedure (see Equation 5.1) includes the interaction INSTR \* CALC, our initial assessment of the results in Table 5.4 begins with this effect. As can be seen from Table 5.4, none of the INSTR\*CALC interaction effects are significant (P-values  $> 0.05$ ) – except for the Pre-test Multiple-choice scores ( $p = 0.02$ ). This implies that both INSTR and CALC have an impact on the Multiple-choice scores, even though their individual “main” effects: INSTR ( $p = 0.20$ ) and CALC ( $p = 0.60$ ) are not significant. That is, the (average) performance of students using the TI-84 was not the same as those using the TI-Nspire for the two types of instruction (Traditional and Intervention).

The interaction effects for the Pre-test mean scores for the four study groups are illustrated by the Interaction Plots in Figure 5.3. This gives a visual representation of the (average) performance “profile” for each type of calculator with respect to the two types of instruction. Clearly, the profiles for the Pre-test Multiple-choice scores are quite different: under the Traditional (TRAD) format, students did better using the TI-84, but the reverse occurred under the Intervention (Inv) format. Visually, the Pre-test Total scores show different profiles, but there was insufficient evidence of a statistically significant interaction effect (Table 5.4,  $p = 0.12$ ). Figure 5.3 also illustrates that a non-significant interaction does not imply that the four study groups performed similarly with regard to the main effects of INSTR or CALC. It does, however, allow us to interpret the results for these main effects separately. From Table 5.4 (ignoring the Pre-test Multiple-

choice MC result), it can be seen that there was a strongly significant CALC effect in both the Pre-test and Post-test scores. Tables 5.2 and 5.3 show that students using the TI-Nspire performed significantly better than the students using the TI-84.

As would be expected, the Pre-test INSTR effect was non-significant (since no intervention had occurred!), but there was (very) weak evidence for the TOTAL and Open-ended OE scores on the Post-test. Students appear to do slightly better under the Traditional format of instruction.

#### *Repeated Measures Procedure*

To account for the expected correlation of a student's performance from Pre-test to Post-test, a repeated measures (RM) analysis of variance procedure was employed.

Using Equation 5.2 as an example, the RM procedure consists of two parts:

- Between Subjects: Was there and overall INSTR effect? (Pre-test and Post-test scores were averaged)
- Within Subjects: Was there a TIME effect and/or a TIME \* INSTR effect? (The averages of Instruction within Pre-test and Post-test were used to assess the TIME effect; TIME \* INSTR indicates whether or not the type of instruction showed consistent results from Pre-test to Post-test. That is, was there an interaction effect?)



Table 5.5

*Repeated Measures Analysis of Variance Tests of Hypotheses for Between Subjects*  
*Effects for the Interaction of Instruction and Calculator*

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Source					
Instr	1	25.97	25.97	2.35	.13
Calc	1	330.78	330.78	29.91	<b>&lt;0.0001</b>
Instr * Calc	1	5.73	5.73	.52	.47
Error	129	1426.80	11.06		
Multiple choice Scores					
Instr	1	1.84	1.84	.63	.43
Calc	1	17.27	17.27	5.9	<b>.02</b>
INSTR * calc	1	13.53	13.53	4.63	<b>.03</b>
error	129	377.38	2.93		
Open-ended Scores					
Instr	1	6.27	6.27	.99	.32
Calc	1	205.85	205.85	32.63	<b>&lt;0.0001</b>
INSTR*Calc	1	3.17	3.17	.5	.48
error	138	870.5	6.31		

Figure 5.2 provides an interaction plot of the (average) performance of the four study groups from Pre-test to Post-test. Several RM analyses were performed with the factors

listed:

1. INSTR + CALC + INSTR \* CALC (Tables 5.5 and 5.6)
2. CALC ( Tables 5.7 and 5.8)
3. INSTR (Tables 5.9 and 5.10)
4. GROUP: Control vs. EXP (E1 + E2 + E3) (Tables 5.11, 5.12 and 5.13)
5. GRP3: E1 vs. Other (E2 + E3 + C) (Tables 5.14, 5.15 and 5.16)

#### Repeated Measures Analysis of INSTR and CALC

##### *Between Subjects Analysis*

Table 5.5 shows that there was a significant CALC effect for all scores (Total  $p = 0.00$ , MC  $p = 0.02$ , OE  $p = 0.00$ ). From Table 5.2 and Figure 5.2 we see that students using the TI-Nspire did consistently better from Pre-test to Post-test. The significant INSTR \* CALC effect ( $p = 0.03$ ) for the Multiple-choice questions is consistent with the GLM analysis earlier in the *Interaction effect* section.. The difference, which we can see from Figure 5.2, is that the TI-Nspire cohort did significantly better on the Post-test.

##### *Within Subjects Analysis*

Table 5.6 shows that there was a strongly significant TIME effect: the students' performance (on average) improved from Pre-test to Post-test (as one would hope!). There was significant evidence of a TIME \* CALC interaction effect for TOTAL ( $p = 0.04$ ) and weak, non-significant evidence for MC ( $p = 0.06$ ) which is evident by the profile separations for the scores. In contrast, there is weak evidence of a TIME \* INSTR interaction effect ( $p = 0.05$ ) for the Open-ended (OE) scores which is reflected by the distinctly steeper profile of the Traditional TI-Nspire cohort as shown in Figure 5.2.

Table 5.6

*Repeated Measures Analysis of Variance Univariate Tests of Hypotheses for Within Subjects Effects for the Interaction of Instruction and Calculator*

Source	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Total Scores					
Time	1	829.13	829.13	146.02	<b>&lt;0.0001</b>
Time * Instr	1	6.95	6.95	1.23	<b>.27</b>
time * Calc	1	24.10	24.10	4.24	<b>.04</b>
Time * Instr * Calc	1	12.67	12.67	2.23	.14
error(time)	129	732.49	5.68		
Multiple-choice					
Time	1	63.00	63.00	25.70	<b>&lt;0.0001</b>
Time * Instr	1	2.41	2.41	.98	.32
time*Calc	1	8.72	8.72	3.56	.06
Time * Instr * Calc	1	3.00	3.00	1.23	.27
error (time)	129	316.26	2.45		
Open-ended					
Time	1	439.72	439.72	134.24	<b>&lt;0.0001</b>
Time * Instr	1	12.53	12.53	3.82	.05
time*Calc	1	6.78	6.78	2.07	.15
Time * Instr * Calc	1	4.92	4.92	1.5	.22
error (time)	138	452.04	3.28		

### *Conclusion*

The results showed that students overall performed significantly better using the TI-Nspire calculator. Similarly, the performance of all cohorts (on average) improved significantly from Pre-test to Post-test. There was weak evidence that the students' performance was related to the type of calculator used at Pre-test versus Post-test for the Total and Multiple-choice scores (see Figure 5.2). But since that was on the Pre-test it was more reflective of a stronger initial performance based on prior academic experience. For the Open-ended scores, there was weak evidence of better improvement under the Traditional instruction format from Pre-test to Post-test.

### *Did the calculator used have an effect on student scores?*

Figure 5.4 graphically presents the mean score data from Table 5.7 for the TI-84 and TI-Nspire groups. The graphs show that the scores of both calculator groups increased, from Pre- to Post-test, on the Multiple-choice questions, Open-ended questions and the Total.

### *Repeated Measures Procedure*

The repeated measures procedure, using Equation 5.2, looked at the question, “Was there an overall Calculator Effect?” using both between and within subjects analyses. Looking at the graphs in Figure 5.4 and the mean scores in Table 5.7, it is evident that the Multiple-choice Pre-test scores were not significantly different for the TI-84 and TI-Nspire groups. The scores for the Open-ended questions and the Total scores were significantly different on the Pre-test. In addition, the students using the TI-Nspire

performed better than the students using the TI-84 on all three test categories. The between and within subjects analyses that is discussed next will shed light on the significance of the changes.

Table 5.7 Calculator Means

Source	N	Total		Multiple-choice		N	Open-ended	
		Pre	Post	Pre	Post		Pre	Post
TI-84	52	4.41	7.4	3.73	4.33	56	0.63	2.90
TI-N	81	6.05	10.25	3.85	5.22	86	2.07	4.92

*Note: Because the structure of the Open-ended Pre-test and Post-test questions*

*(scores 0 – 3) was different from the Multiple-choice questions (scores from 0 – 1), we decided to use the full cohort of permissions available (142 instead of 133)*

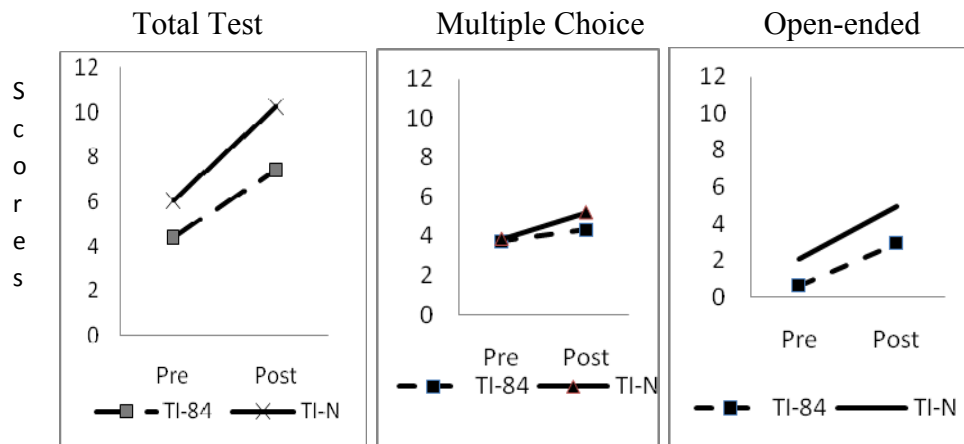


Figure 5.4. Graphs for the change in mean scores from Pre-test to Post-test by type of Calculator

#### *Between Subjects Analysis*

Table 5.8 shows that there was a significant Calculator effect for all scores,

Multiple-choice, Open-ended and Total. From Figure 5.4 we see that the students using the TI-Nspire performed consistently better than the students using the TI-84 did. The difference in the mean scores (on average) was strongly significant for the Total and the Open-ended scores and significant for the Multiple-choice questions. This is consistent with the findings from the comparison of the four study basic groups.

Table 5.8

*Repeated Measures Analysis of Variance Tests of Hypotheses for Between Subjects Effects for Calculator*

Source	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Total Scores					
Calc	1	319.03	319.03	28.73	<b>&lt;0.0001</b>
Error	131	1454.48	11.10		
Multiple-choice Scores					
Calc	1	16.36	16.36	5.48	<b>.02</b>
Error	131	391.19	2.99		
Open-ended					
Calc	1	204.25	204.25	32.40	<b>&lt;0.0001</b>
Error	140	882.49	6.30		

*Within Subjects Analysis*

Table 5.9 shows that, consistent with our previous findings, there was, as expected, a strongly significant TIME effect in scores. There was weak evidence of a

TIME\*CALC interaction effect for Total ( $p = 0.05$ ) and Multiple-choice ( $p = 0.05$ ) scores. The students using the TI-Nspire showed greater change in mean scores, over time, than the students using the TI-84. There was no evidence of a significant difference in student performance on the Open-ended questions ( $p = 0.20$ ).

Table 5.9

*Repeated Measures Analysis of Variance Univariate Tests of Hypotheses for Within Subjects Effects for Calculator*

Source	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Total Scores					
time	1	820.30	820.30	141.88	<b>&lt;0.0001</b>
time*Calc	1	22.71	22.71	3.93	.05
error(time)	131	757.42	5.78		
Multiple-choice Questions					
time	1	61.24	61.24	25.01	<b>&lt;0.0001</b>
time *Calc	1	9.49	9.49	3.88	.05
error	131	320.7	2.45		
Open-ended questions					
Time	1	443.96	443.96	131.12	<b>&lt;0.0001</b>
time *Calc	1	5.72	5.72	1.69	.20
error	140	474.01	3.39		

### *Conclusion*

The calculator used made a difference. Students using the TI-Nspire (E1 + E3), on average, performed significantly better than the students using the TI-84 (E2 + C) on the Multiple-choice, Open-ended and Total test scores. There was weak evidence of the TI-Nspire having an effect over time on the Total and Multiple-choice scores. There was no interaction effect on the Open-ended questions, which means that, over time, neither groups showed a significantly greater change in their mean scores.

Method of instruction used between and within subjects analyses that is discussed next will shed light on the significance of the changes.

*Did the instructional unit have an effect on student scores?*

### *Repeated Measures Procedure*

Our next investigation, using Equation 5.2, looked at the question, “Was there an overall Instruction effect?” using both between and within subjects analyses. Looking at Table 5.10 and the graphs in Figure 5.5, it is evident that the scores on the Pre-test were not significantly different for any of the three categories of scores. Visually, it appears that the students using the Traditional Curriculum performed better overall on the Total and Open-ended sections and the students using the Intervention Curriculum did better on the Multiple-choice questions. The between and within subjects analyses will examine the scores to see if there were any significant difference in the instructional methods.

### *Between Subjects Analysis*



There was no significant difference, on average, between the Total ( $p = 0.34$ ) scores, Multiple-choice scores ( $p = 0.87$ ) or Open-ended ( $p = 0.56$ ) scores for the independent variable Instruction.

### *Within Subjects Analysis*

Table 5.11 shows that there was a strongly significant TIME effect. There was significant evidence of a TIME\*INSTR effect for the Open-ended scores. Pre-test to Post-test the students using the Traditional Curriculum (E3 + C) performed significantly better than the students in the Intervention Curriculum.

Table 5.10

### *Curriculum Means*

Source	N	Total		Multiple-choice		N	Open-ended	
		Pre	Post	Pre	Post		Pre	Post
Inv	67	5.39	8.73	3.7	4.94	69	1.64	<b>3.78</b>
Trad	66	5.42	9.55	3.91	4.8	73	1.37	<b>4.44</b>

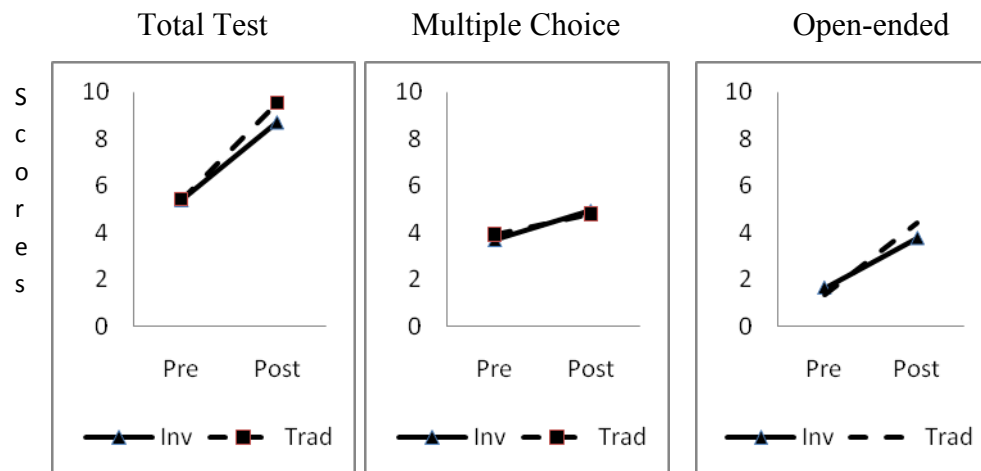


Figure 5.5 Graphs for the change in mean scores from Pre-test to Post-test for

instructional study groups

### *Conclusion*

The instructional method used was not significant for the Multiple-choice and Total scores. The Traditional Curriculum (E3 + C) was more effective in preparing students for Open-ended questions than the Intervention Curriculum (E1 + E2). The students in the Intervention Curriculum were not accustomed to project-based learning and may not have

Table 5.11

### *Repeated Measures Analysis of Variance Univariate Tests of Hypotheses for Within Subject Effects for Instructional Study Groups*

Source	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>P</i>
Total Test					
Time	1	926.27	926.27	157.57	<b>&lt;0.0001</b>
time *INSTR	1	10.06	10.06	1.71	.19
error(time)	131	770.07	5.87		
Multiple Choice					
Time	1	75.62	75.62	30.17	<b>&lt;0.0001</b>
Time * INSTR	1	1.98	1.98	.79	.38
error(time)	131	328.22	2.51		
Open-ended Questions					
Time	1	482.06	482.06	145.26	<b>&lt;0.0001</b>
Time * INSTR	1	15.13	15.13	4.56	<b>.03</b>
error (time)	140	464.60	3.31		

been comfortable with this approach to learning. Additional comparisons of cohorts were conducted in order to assess differences.

*Was there a difference between the Control group and the rest of the groups combined?*

#### *Repeated Measures Procedure*

Repeated measures procedures, using Equation 5.2 to see if there was a difference in the performance of the Control (C) group versus the Experimental group (E1 + E2 + E3) using both between and within subjects analyses. Looking at Table 5.12 and the graphs in Figure 5.6, it is evident that the scores on the Pre-test were not significantly different for the Total test. The Multiple-choice scores intersect so there was no significant difference between the scores although there might be an interaction effect. The Experimental group started the unit with better scores and ended with better scores for the Open-ended scores. The between and within subjects analyses examined whether the differences are significant.

Table 5.12

#### *Group Means*

		Total			Multiple-choice			Open-ended	
Source	<i>N</i>	<i>Pre</i>	<i>Post</i>		<i>Pre</i>	<i>Post</i>	<i>N</i>	<i>Pre</i>	<i>Post</i>
Cont	28	4.89	7.79		4.21	4.43	32	0.59	3.00
Exp	105	5.54	9.50		3.70	4.99	110	1.76	4.45

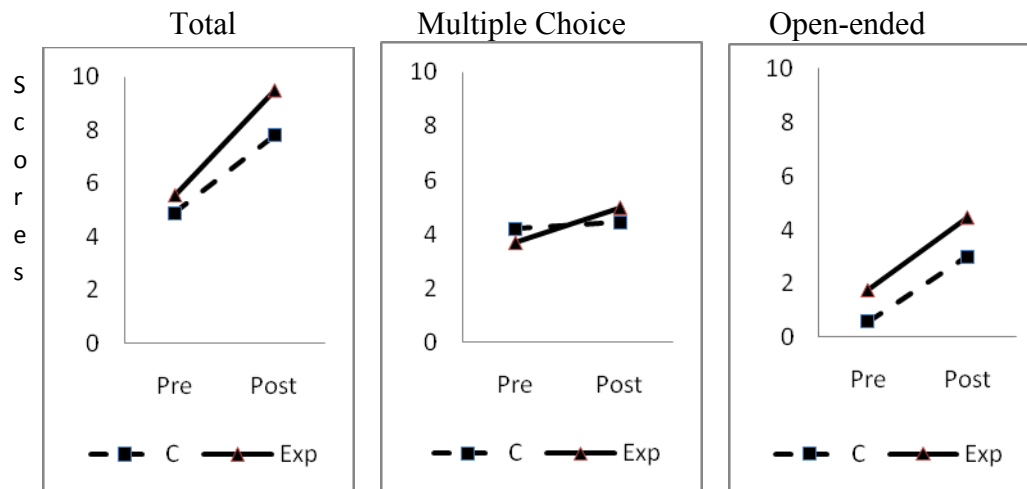


Figure 5.6 Graphs for GROUP and Control change in mean scores from Pre-test to Post-test

#### *Between Subjects Analysis*

There was a significant difference, on average, between the groups on the Total ( $p = 0.03$ ) scores and a strongly significant difference on the Open-ended ( $p < 0.005$ ) scores (Table 5.13). The Experimental group did significantly better than the Control (C) group. There was no significant difference on the Multiple-choice ( $p = 0.94$ ) questions. This is apparent from the intersection of the graphs.

#### *Within Subject Analysis*

There was a significant TIME effect. The interaction of TIME \* GROUP was not significant for the Total scores ( $p = 0.15$ ) or for the Open-ended ( $p = 0.60$ ) questions but it was significant for the Multiple-choice ( $p = 0.02$ ) questions.

The students in the Experimental group (E1 + E2 + E3) performed significantly better on the Multiple-choice scores Pre-test to Post-test. The Control

(C) group showed very little change in performance from Pre-test to Post-test on the Multiple-choice scores while the scores for the students in the Experimental group went up significantly.

Table 5.13

*Repeated Measures Analysis of Variance Tests of Hypotheses for Between Subjects*

*Effects for GROUP*

Source	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Total Score					
GROUP	1	61.53	61.53	4.71	<b>.03</b>
error	131	1711.98	13.07		
Multiple choice					
GROUP	1	0.02	0.02	0.01	.94
error	131	407.53	3.11		
Open-ended					
GROUP	1	84.78	84.78	11.85	<b>&lt;0.0001</b>
Error	140	1001.95	7.16		

*Conclusion*

There was a significant difference between the performance of the students in the Control and Experimental groups on the Total scores and on the Open-ended scores. On average, the students in the Experimental group scored significantly better than the students in the Control group for both comparisons. The within subjects analysis showed

that, over time, the students in the Experimental group scored significantly better on the Multiple-choice questions. There was no significant difference, over time, on the Open-ended and Total scores.

Table 5.14

*Repeated Measures Analysis of Variance Univariate Tests of Hypotheses for Within Subjects Effects for GROUP*

Source	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Total Scores					
time	1	517.90	517.90	88.37	<b>&lt;0.0001</b>
time*GROUP	1	12.41	12.41	2.12	.15
Error (time)	131	767.72	5.86		
Multiple Choice					
time	1	25.19	25.19	10.40	<b>&lt;0.0001</b>
time*GROUP	1	12.92	12.92	5.33	<b>.02</b>
error (time)	131	317.28	2.42		
Open-ended					
time	1	320.87	320.87	93.82	<b>&lt;0.0001</b>
time*GROUP	1	0.94	0.94	0.28	.60
error (time)	140	478.79	3.42		

*Was there a difference between the Inv TI-N group (E1) and Grp3 (E2 + E3 + C)?*

*Repeated Measures Procedure*

Table 5.15 and Figure 5.7 show that the students in the Intervention TI-Nspire group outperformed the rest of the students (Grp3). It appears from the graphs that the students in Grp3 showed greater gains in mean scores on the Total and Open-ended scores while the students in group E1 did better on the Multiple-choice questions. Using Equation 5.2, between and within subject analyses were conducted to see if these observations were significant.

Table 5.15

*Grp3 Means*

Source	N	Total		Multiple-choice		Open-ended	
		Pre	Post	Pre	Post	Pre	Post
E2 + E3 + C	90	5.00	8.85	3.71	4.64	1.20	4.02
Inv TI-N	43	6.26	9.72	4.00	5.35	2.16	4.33

*Between Subjects Analysis*

There was sufficient evidence to conclude that there was a difference between E1 and Grp3 on the Total ( $p = 0.03$ ) and Multiple-choice scores ( $p = 0.03$ ) and weak, non-significant evidence that the Open-ended ( $p = 0.07$ ) scores were different (see table 5.16). Group E1, the Intervention TI-Nspire group outperformed Grp3.

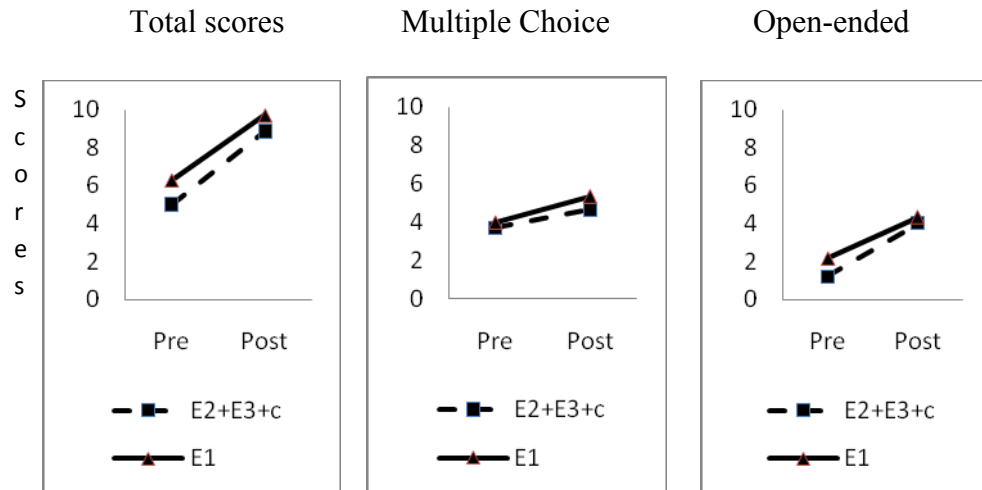


Figure 5.7 Graphs for Grp3 and InvTI-N change in mean scores from Pre-test to Post-test

Table 5.16

*Repeated Measures Analysis of Variance Tests of Hypotheses for Between Subjects*

*Effects for Grp3*

Source	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Total Scores					
Grp3	1	65.46	65.46	5.02	<b>0.03</b>
Error	131	1708.05	13.04		
Multiple Choice Scores					
Grp3	1	14.35	14.35	4.78	<b>0.03</b>
error	131	393.19	3.00		
Open-ended Scores					
Grp3	1	24.88	24.88	3.28	0.07



Error	140	1061.85	7.58
-------	-----	---------	------

### *Within Subjects Analysis*

There was a strongly significant TIME effect. There was no significant TIME\*Grp3 effect. (see Table 5.17).

Table 5.17

### *Repeated Measures Analysis of Variance Univariate Tests of Hypotheses for Within Subjects Effects for Grp3*

Source	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Total Scores					
Time	1	779.71	779.71	131.30	<b>&lt;0.0001</b>
time * Grp3	1	2.22	2.22	0.37	.54
Error (time)	131	777.91	5.94		
Multiple Choice Scores					
Time	1	75.78	75.78	30.29	<b>&lt;0.0001</b>
time * grp3	1	2.50	2.51	1.00	.32
error (time)	131	327.68	2.50		
Open-ended Scores					
Source	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Time	1	384.63	384.63	113.77	<b>&lt;0.0001</b>
time * Grp3	1	6.43	6.43	1.90	.17
Error (time)	140	473.30	3.38		

### *Conclusion*

The students in group E1 outperformed those in Grp3. The scores between the groups were significant for the Total and Multiple-choice scores and weak, non-significant evidence for the Open-ended scores. There was no significant difference in the performance of the two groups over time for any scores.

### Summary of Study Group Comparisons

There was, as expected, a strongly significant TIME effect. The scores of every group and cohort increased over time. The average mean score for the students using the TI-Nspire (E1 + E3) was higher than the mean scores for the students using the TI-84 (E2 + C) on all three categories of scores. However, these differences were only significant for the Total test scores. The students using the TI-Nspire showed weak evidence of outperforming the students using the TI-84 on the Multiple-choice portion of the test. The calculator used did not have a significant effect on the Open-ended questions. Concentrating on the mechanics of using the TI-Nspire instead of on the analysis of the data may have been a contributing factor.

The Traditional Curriculum (E3 + C) was more effective in preparing students for Open-ended questions than the Intervention Curriculum (E1 + E2). Possibly this is because the students using the Intervention Curriculum were not accustomed to project-based learning and may not have been comfortable with this approach, particularly because the unit was designed to be student-directed and not teacher-directed. Another possibility is that the project the students did was not effective for helping students

master open-ended data analysis questions. Many of the students were not comfortable with this, as was reflected in the negative response on the student attitudinal survey question, “Teachers explain Open-ended questions very well.”

The within subjects analysis showed that both the instructional method and the calculator used (INSTR\*CALC was significant) had an effect on the Multiple-choice scores. The interaction of INSTR\*CALC was not a significant factor on the Total test or the Open-ended questions. On the Multiple-choice questions there was significant evidence to suggest that the Intervention Curriculum was more effective than the Traditional Curriculum.

The Control (C) group did not perform as well as the Experimental group on any scores. The difference between the groups was significant for the Total test and on the Open-ended scores but not the Multiple-choice scores. The students in the Control group did not score as well as those in the Experimental group on the within subjects Multiple-choice analysis.

The students in the Intervention TI-Nspire group (E1) did significantly better on the Total test and the Multiple-choice questions and showed weak evidence of performing better on the Open-ended questions. Although the students in Grp3 had larger increases in scores on the Total and Open-ended scores, the differences, Pre-test to Post-test, were not significant. The within subjects comparison showed no significant difference between the two groups on any scores.

These results, in combination with the results of the qualitative data analysis helped me answer research question # 1.

*What is the effect of a problem/project-based instructional unit on ninth grade basic skills mathematics students' understanding of how to represent, interpret and analyze real world data as measured by their performance on questions similar those in the Data Analysis Cluster of the NJ HSPA?*

The analysis showed that the Traditional Curriculum (E3 + C) more effectively prepared students for Open-ended questions than the Intervention Curriculum (E1 + E2). Student comfort level with project-based and student-centered learning may have influenced the effectiveness of this approach, as was reflected in the negative response on the student attitudinal survey question, "Teachers explain Open-ended questions very well."

The instructional method did not make a difference on the Total score or the Multiple-choice questions. Next, we will look at the effect of the calculator the students used as we look at Research Question #2.

*What is the effect of using the document features of the TI-Nspire in a data analysis unit on the students' mastery of related tools and concepts?*

The students using the TI-Nspire (E1 + E3) outperformed the students using the TI-84 (E2 + C) except on the Open-ended questions. As discussed earlier the students using the TI-Nspire had quite a steep learning curve with their handheld. This may have affected their level of proficiency at analyzing data. The gains on the Open-ended scores were not significant for either calculator group.

It was hard to separate the effect of the document features of the TI-Nspire from

the overall effect of the calculator. Although the students did not like taking notes and answering questions on the handheld, they seemed to have benefitted from having the unit of instruction all in one place. Many of the students liked going back and referring to previous data and graphs. However, the problems in the Intervention Curriculum were lengthy (in terms of calculator pages) which made negotiating the pages difficult for some students. The Traditional group using the TI-Nspire had the advantage of being able to go back and look at previous graphs and data without all the information about the problems in their way. The data and graphs were in the calculator, but the problems were on paper, which created fewer calculator pages to negotiate. This group seems to have benefitted from the ability to go back and look at previous work. Many of these students reported that they liked being able to refer to previous work. The document features seemed to help them master the concepts in the data analysis unit.

Now let us look at the effect of the interaction of instruction and calculator as we answer Research Question # 3.

*What is the effect of the combination of the document features of the TI-Nspire handheld and the problem/project-based unit of instruction on the students' mastery of related tools and concepts?*

The interaction of instruction and calculator used recorded weak, nonsignificant results for the Multiple-choice questions. The Traditional TI-Nspire group (E3) outperformed the other three groups in this category. The Total test and Open-ended scores did not show a significant difference when all four study groups were looked at together. When we looked at some of the cohorts, we did see significant differences.

The Multiple-choice and Total test scores were significant in the comparison between the students in the Control (C) group and the students in the Experimental group (E2 + E3 + C). The Experimental group outperformed the Control group.

In the comparison between the performance of students in the TI-Nspire Intervention (E1) group and Grp3 (E2 + E3 + C), group E1 significantly outperformed Grp3 on the Total and Multiple-choice scores and exhibited weak, non-significant evidence of outperforming them on the Open-ended. There was no within subjects difference in any of the scores.

The researcher concludes that, although the students in E1 outperformed the rest of the students, over time, there was not a significant difference in the groups. The combination of the Intervention Curriculum and the TI-Nspire did not have as great an effect overall as the researcher predicted it would.

## CHAPTER 6: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter is a summary of the present study from beginning, through design and implementation, to the analysis and findings. The findings are presented in the concluding sections of this chapter.

### Summary

#### *Purpose of the Study*

The purpose of this study was to determine whether a problem/project-based unit of instruction on the material covered in the NJ HSPA Data Analysis cluster, (the New Jersey High School Proficiency Assessment) was a more effective method of instruction than the Traditional Curriculum. It also looked at the effect of using the TI-Nspire handheld, a document based calculator instead of the TI-84, the standard calculator issued at our school. Data analysis was selected for the unit of instruction because our students traditionally score poorly on that portion of the state standardized test. Questions on the state test require that students be able to decide what type of graph was best for a given set of data, be able to construct graphs, and be able to interpret graphs and data.

#### *Research Design*

This study was carried out during the 2008-2009 school year, in a northern New Jersey Vocational-Technical High School. The school is a county school and enrolls approximately 3000 students. The students in the study were all freshmen in remedial mathematics classes. There were twelve classes in the study, divided into four groups, Control (C) -Traditional Curriculum using the TI-84 calculator, E2 - Intervention Curriculum using the TI-84 calculator, E1 - Intervention Curriculum using the TI-Nspire

handheld and E3 -Traditional Curriculum using the TI-Nspire handheld. A four-week problem-/project-based unit of instruction served as the treatment for this experiment. Two teachers used the TI-Nspire handhelds and one teacher used the TI-84 calculators. The classes were as equivalent as possible, given the constraints at the study site.

This study had a quasi-experimental Pre/Post-test design enhanced by a qualitative component. A four-week unit, divided into four parts, served as the treatment for this experiment. The data in the first part of the treatment curriculum looked at population data for the country, state, county, and one local town. Students compared and contrasted the data by ethnic groups. The data in the second part focused on wages, delimited by gender and ethnicity. Data from the U.S. Bureau of Labor and Statistics, subdivided into the following ethnicities: All, White, Black, Asian, Hispanic and Other was used. Students were required to analyze the different sets of data and to rearrange the data sets for further analysis. The students tried to discern why there were differences between various groups. During the first part of the unit, the students worked together on a predesigned series of activities. Then the students selected the groups they wished to compare and created a small project based on their selection. The final part of the instructional unit was a project where students, working in groups, explored wage and employment statistics for the particular career they are preparing to enter and presented this project to the class.

Pre-test and Post-tests were analyzed for the four study groups and cohorts. GLM tests were done on the four study groups, followed by Repeated Measures Analysis of Variance Tests of Hypotheses for Between Subjects Effects and Repeated Measures



### Univariate Tests of Hypotheses for Within Subjects Effects.

The quantitative component of the attitudinal section of this study analyzed the differences between the quantified responses on the attitudinal survey before and after the unit of instruction. Comparisons were made for each of the four study groups.

The qualitative component of this study was designed to look closely at students' attitudes about mathematics, the methodology of instruction and the calculator used during the unit of instruction. Student volunteers participated in group interviews, with each study group interviewed separately. The group interviews included students from different classes to get a broader perspective on student attitudes before, during and after the unit of instruction. Individual teacher interviews were also conducted to add the teachers' perspective about student attitudes and to help assess what students learned during the unit. The qualitative data was analyzed to find common themes within each group and among the different groups.

### Summary of Attitudinal Findings

The evidence suggested that the students in the Control (C) group had little self-reported change in attitude. The only positive attitudinal changes for this group were in students' attitudes towards their ability to find outliers and to interpret scatter plots. These students had a negative attitudinal change when it came to understanding the text or story in Open-ended questions. During the group interviews, this group said they were more confident with open-ended questions now than they were before the unit of instruction. They felt that drawing most types of graphs was not hard, but it was easy to get messed up plotting data or drawing sectors of circle graphs.

While the evidence suggested that the students in the Experimental (E1 + E2 + E3) group had positive changes in their attitudes towards their ability to draw histograms, the evidence also suggested that the Control (C) group had weak, non-significant negative changes in attitude for the same statement.

The students in the Intervention Curriculum (E1 + E2) group showed positive changes in attitude in the following areas; statements regarding Open-ended questions, interpreting statistics and creating and interpreting graphs. The group interview with the students in E2 revealed that the students found the material confusing. They found it hard to keep track of their lists and were sometimes confused with the detailed instructions as to 'what buttons to push'. Despite these complaints, the students felt that they had learned a lot by working with the same data for multiple problems, but also found it boring. The interviewees in group E3 felt that they were not good at drawing some of the graphs, but felt that they understood how to interpret them. This group also complained about not remembering the sequence of buttons to push in order to create various graphs.

In the comparison between the TI-Nspire Intervention (E1) group and Grp3 (E2 + E3 + C), the evidence suggested significant positive changes in the attitudes of students in both groups when responding to statements about creating graphs, interpreting graphs and in the students self reported overall change in attitudes. Students in both groups showed positive changes in attitudes when responding to statements about scatter plots and histograms.

Evidence showed that the students in the TI-Nspire Intervention (E1) group had some significantly negative changes in attitude when it came to drawing bar graphs and

circle graphs. In the interview with students from this group, there was considerable discussion about drawing graphs by hand versus letting the calculator do it. Some felt that using the calculator was 'cheating'. The students in the Intervention Curriculum (E1 + E2) did not spend much time on bar graphs. The graphs were drawn by the calculator and interpreted by the students. Circle graphs were also drawn by calculator rather than by hand. This may have affected the students' attitudes when asked about drawing graphs. The students seemed to differentiate between drawing and making graphs. Making graphs did not score as significant a change in attitude as drawing them did. The Intervention Curriculum (E1 + E2) group also had a negative change in attitude about teachers doing a good job of explaining Open-ended questions. The problem/project approach was more student-centered and less teacher-directed. The students may have interpreted this teaching approach as the teachers not explaining these types of questions well.

Students in all four groups felt comfortable with data analysis. Most students agreed that it was nice to let the calculator do the work, but some students felt that it was important to be able to create the graphs, to draw the line of best fit, and to do the mathematical computation for mean, median and mode by hand.

Students in the Intervention Curriculum (E1 + E2) groups found the material in the unit too repetitive, although most agreed that by the end they were very comfortable with comparing different sets of data. In contrast, the students in the Traditional Curriculum (E3 + C) groups liked having the variety of data sets but would have enjoyed some in-depth analysis using the same data for multiple types of analysis. Most of the students said the final project, which they did on their own, was difficult, because they

could not find the data they wanted for their individual occupations. They could find general data, but the data was not broken down by gender and ethnicities. This was frustrating for them. Some students said that they would rather have picked their own topics for the projects.

The teachers said that the projects demonstrated that the students understood and were comfortable with data analysis concepts taught in the unit. They said that the groups all presented projects which reflected the talents of the students in each particular group. Unfortunately, I did not get to see the projects because of permission slip issues. The projects were all group projects and I did not have permission from all students in any group to look at the projects. Their comments were helpful, but I would have gained more insight if I had seen the projects myself.

Typically, in a project-based unit the students pick their own topics. For consistency within all the Intervention Curriculum (E1 + E2) classes, I decided that because our school is a vocational-technical school and every student is preparing for a career, using data about their own careers would allow enough individuality. However, the lack of easily accessible data seemed to stifle the students' creativity. The students were easily frustrated when they could not find the data they wanted to use. The data they found was not delimited the same way it was in the unit and the students were not insightful enough to create a project with the data they did find. They were not accustomed to doing projects and tried to mimic the problems done in class instead of designing their own. Future projects need to consider the advantages and disadvantages of allowing more student decisions about what they will investigate.

The students in the TI-84 (E2 + C) group and TI-Nspire (E1 + E3) groups both showed significant positive changes in their responses to statements about interpreting scatter plots and finding outliers. The students using the TI-Nspire also showed positive changes in attitude towards interpreting statistics and graphs, including drawing the line of best fit and predicting from that line. They also had positive changes when asked about creating graphs, specifically histograms and scatter plots.

The students in the TI-84 (E2 + C) groups showed weak, non-significant negative changes in attitude towards understanding Open-ended questions. This means that either the students scored had positive attitude on the Pre-test and a negative attitude on the Post-test or vice versa. They found the calculator easy to use. The TI-84 calculator does not have the capability of drawing circle graphs so the students in the TI-84 groups had to draw all of their circle graphs by hand. Some students felt that it would have been nice if the calculator could draw the graphs for them. Others felt that circle graphs were easy to do by hand. Students in the TI-84 groups (E2 + C) had to enter the data by hand, but they did not seem to mind this.

In contrast to the students in the TI-84 group, students using the TI-Nspire (E1 + E3) found the calculator difficult to use. Some of the students appreciated having the data already in the calculator and others felt they would have liked to enter the data themselves. Most of the students did not like having to write answers in the calculator, because it was too time-consuming. They found the keys too small, making it hard to write quickly and reported that their speed of writing was hampered by the arrangement of the keys, alphabetically instead of QWERTY. Some of the students liked being able to

go back to look at prior work and at prior instructions, but others felt that it took too much time going back and forth between pages. In March 2010, Texas Instruments changed the face of the TI-Nspire so that the ALPHA keys are all located at the bottom of the face. The keys are still in alphabetical order (to allow use on SAT type tests) but they are more easily accessible.

The teacher interviews corroborated the student opinions. The TI-Nspire teachers mentioned calculator difficulties. They agreed that the students did not like taking notes on the calculator because it was too time consuming, but they felt that the students liked being able to go back to previous work to compare and contrast their graphs. If the questions were not on the calculator, but on separate paper handouts, the number of calculator pages would have decreased, perhaps making it easier for students to look at previous graphs.

### Summary of Quantitative Findings

The quantitative analysis on the Pre-test and Post-test Total scores, Multiple-choice scores and Open-ended scores was designed to answer these research questions:

1. What is the effect of a problem/project-based instructional unit on ninth grade basic skills mathematics students' understanding of how to represent, interpret and analyze real world data as measured by their performance on questions similar those in the Data Analysis Cluster of the NJ HSPA?
2. What is the effect of using the document features of the TI-Nspire in a data analysis unit on the students' mastery of related tools and concepts?
3. What is the effect of the combination of the document features of the TI-

Nspire handheld and the problem/project-based unit of instruction on the students' mastery of related tools and concepts? Pre-test and Post-test scores were used to measure changes in student performance.

### *Method of Analysis*

The first test done was the GLM analysis of the four study groups, using the equation  $Y = INSTR + CALC + INSTR * CALC$  where  $y = MC, OE$  or  $TOTAL$  and  $INSTR * CALC$  denotes the *interaction* effect. Note that a 'significant' interaction implies that the effect of  $CALC$  is **NOT** the same at each level of  $INSTR$ .

By convention, for all our comparisons, a  $P\text{-value} < 0.05$  was 'statistically significant evidence against  $H_0$ '. That is, we said we "reject  $H_0$ ". If  $.05 < \alpha < .10$  we said there was weak evidence to support the claim that there was a non-significant difference in the groups being compared. However, because the concept of  $H_0$  is inferential, we are implying that these results apply to ALL students (in the target population). Clearly, this study has not encompassed the entire target population so we use the  $P$ -value to assess the likelihood that  $H_0$  could be true.

Following the GLM, Univariate Repeated Measures ANOVA analyses were done. This method (RM) evaluates both the Pre-test and Post-test results simultaneously with respect to a factor and, hence, accounts for the expected correlation between a student's performance on these tests. Both 'Between Subjects' and 'Within Subjects' analyses were carried out.

### *Effect of Calculator*

The pre-test average mean scores for the TI-Nspire groups were higher than the pre-test average mean scores for the TI-84 groups. The between subjects analysis showed that difference in mean scores, pre-test to post-test was significant for the Total test scores but not for the Multiple-choice scores and the Open-ended scores. The within subjects analysis showed that, over time, the scores on the Multiple choice portion of the test were significantly higher for students using the TI-Nspire. The calculator used on the Open-ended portion of the test was not significant.

The steep learning curve for the students using the TI-Nspire may have affected the Open-ended scores. Concentrating on how to perform the data analysis, rather than on the analysis itself may have contributed to smaller gains in understanding for the TI-Nspire group on that portion of the post-test.

### *Effect of Instructional Method*

The students using the Traditional Curriculum scored significantly better, over time, on the Open-ended questions than the students using the Intervention Curriculum. The curriculum used did not have a significant effect, over time, on either the Multiple-choice or Total scores. The students using the Traditional Curriculum performed significantly better on the Open-ended questions.

Whether it was a lack of calculator proficiency at the beginning of the study unit or the Intervention Curriculum itself that may have resulted in this poorer performance on Open-ended questions is not clear. The students may have been so concerned with the calculator mechanics that they did not absorb the material or the Intervention Curriculum



may not have been effective at preparing students for Open-ended questions. Another contributing factor was the student's lack of familiarity with problem/project-based learning. The students were not able to do the in depth analysis expected of them during the unit of instruction. This lack appears to indicate that did not master the concepts well enough to transfer their knowledge to new situations.

Overall, the unit of instruction did not have as much effect on performance as the calculator did.

#### *Effect of the Interaction of Instruction and Calculator*

The within-subjects analysis INSTR\*CALC was significant for the difference in the pre-test Multiple-choice mean scores. The interaction INSTR\*CALC was not a significant factor for the difference in the pre-test mean scores for the Total test or the Open-ended questions.

There was an INSTR \* CALC effect ( $p = 0.03$ ) on the between subjects difference in mean scores pre-test to post-test. The Intervention Curriculum was significantly more effective than the Traditional Curriculum on the Multiple-choice questions.

When the Traditional TI-84 group was compared to everyone else (the Experimental group), they did not do as well. The students in the Experimental group did significantly better on the between subjects comparisons for Total score and Open-ended scores. On the within subjects analysis the Experimental group did better on the Multiple-choice questions.

## Conclusions

The students using the Traditional Curriculum outperformed the students using the Intervention Curriculum on the Total and Open-ended parts of the Pre-test and Post-test. The difference between the groups was not significant but the difference within the groups was significant for the Open-ended scores. The students using the Intervention Curriculum outperformed (over time) the students using the Traditional Curriculum on the Multiple-choice questions, but the difference was not significant.

This study was hampered by the students' lack of familiarity with the TI-Nspire and the students' lack of prior exposure to problem/project-based learning in mathematics. It is not uncommon for students to have "difficulties benefiting from self-directed situations, especially in complex projects. Chief among these difficulties are those associated with initiating inquiry, directing investigations, managing time, and using technology productively" (Thomas, 2000, p. 23.)

The students in both the Intervention group and the Traditional group had many positive attitudinal changes towards mathematics and data analysis.

Figure 6.1 shows the change in means on the Total test, Pre-test to Post-test. Visually, it is evident that the students using the Traditional Curriculum with the TI-Nspire showed the greatest change of the four study groups in performance on Total test scores and Open-ended scores. The students in the Intervention Curriculum group had higher changes in mean scores on the Multiple-choice questions. The rest of the results were not easy to interpret. The students in the Intervention TI-Nspire group, the Intervention TI-84 group and the Control group appear to have made similar gains on the

Total and Open-ended parts of the test over time.

The students in the Traditional TI-Nspire group, (mean scores up 1.42), the Intervention TI-Nspire group, (mean scores up 1.35) and the Intervention TI-84 group, (mean scores up 1.04), had similar mean score gains on the Multiple-choice questions from pre-test to post-test. The Control (C) group (mean scores up .22) students did not perform as well (over time) as these groups on the Multiple-choice questions. Both TI-Nspire groups outperformed the TI-84 groups.

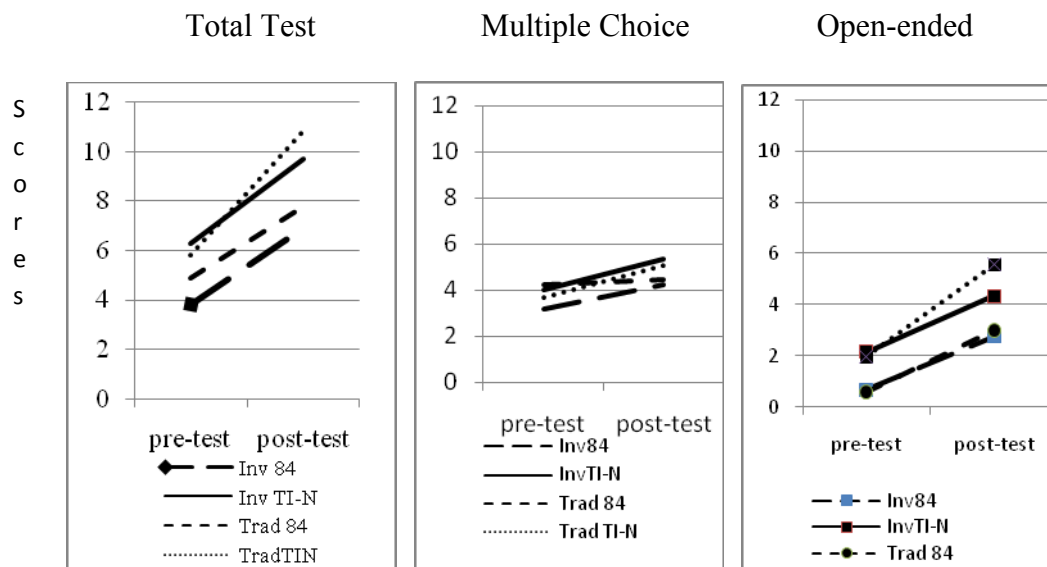


Figure 6-1 Change in Means, Pre-test to Post-test Scores for the Four Basic Study Groups

On the Open-ended questions students in both of the Traditional Curriculum groups showed larger changes in mean scores from pre-test to post-test (Traditional TI-84 ( mean score up 2.41), Traditional TI-Nspire (mean score up 3.59) than the two Intervention Curriculum groups, Intervention TI-84 (mean score up 2.08), Intervention TI-Nspire (mean score up 2.18). The students in the two TI-Nspire (Traditional and Intervention) groups outperformed the students in the two TI-84 (Traditional and

Intervention) groups (see Figure 6.1).

### Summary

The study showed mixed results. Students using the TI-Nspire showed larger gains in the mean scores for the Total test, Multiple-choice scores and Open-ended scores when both the calculator and the instructional method were considered. When looking only at the calculator, the students in the TI-Nspire (E1 + E3) group showed greater improvement on the Total scores and on the Multiple-choice questions but the students in the TI-84 (E2 + C) group did better on the Open-ended questions.

Interviews with both students and teachers showed that the student, particularly those in the Intervention TI-Nspire group, did not like taking notes and answering questions on the TI-Nspire. Dr. Steven Arnold, referring to the notes feature of the TI-Nspire says, “TI-Nspire offers an additional tool in this regard, supporting students in entering their own responses within the document, forcing them to verbalize (ideally in both spoken and in written forms). This will be unfamiliar ground initially, for both teachers and students” (Arnold, 2010, p. 5). The dislike of the notes feature was partially because of the size and layout of the alphabetical keys on the TI-Nspire and partially because the students did not like to write answers to Open-ended questions. Some of the students liked having the information in the calculator to refer back to and others felt it was too time consuming. The students in the Traditional TI-Nspire group liked going back in their document more than the students in the Intervention TI-Nspire group because they had their work, but not all the questions and directions, making it easier to negotiate the pages.

The TI-Nspire Intervention Curriculum was divided into three problems and each one had 30 – 50 calculator pages. Although this is only 15-20 full size pages, navigating between this many pages was difficult. The unit was constructed to make the data easily accessible for manipulation but the large number of pages made it hard to go back to previous graphs. Too much information may have hindered the students rather than helping them. “Limitations do exist, of course, and it is not envisaged that the documents become too large and unwieldy” (Arnold, 2010, p. 7).

Mental and social maturity may also have been a factor in student response to the problem/project approach. The teachers who taught the unit felt that older students would have done better with this approach. John Thomas states, “One challenge is sustaining motivation for inquiry. Students often failed to participate or participated in a disengaged manner....Students often lacked background knowledge necessary to make sense of the inquiry. ....Students were often unable to manage extended inquiry activities” (Thomas, 2000, p.23). In this study, a lack of student comfort with project-based learning may also have affected the outcome.

Project/problem-based learning was new to the teachers as well as the students. The teachers were given some basic professional development on project-based learning, but it appears that additional development related to this method of teaching might have been helpful. That is, significant professional development related to teaching using problem and project-based learning might have helped strengthen the teachers’ confidence and delivery of the Intervention Curriculum.

## Recommendations

### *Implication for Teaching*

The evidence suggested that the all of the study group showed a greater change in mean scores than the Control (C) group on the Multiple-choice, Open-ended and Total tests scores. However, the Traditional group (the Control group is in this group) showed a greater change on the Open-ended questions. The performance of the Control group suggests that we should consider changing the way we teach data analysis to our students. However, change needs to be introduced gradually. Introducing a new method of instruction in a major unit of instruction mid-year, along with reintroducing a new calculator (used for 10 weeks and then not used for 10 weeks), appears to have been overwhelming for our participating students. As curriculum coordinators, administrators and teachers seek ways to better teacher our students, consideration must be given to both the method of instruction used and the technology used. Changing either the calculator or the method of instruction instead of trying to do both at the same time might prove to be more effective than changing both at the same time.

This researcher suggests that introducing problem/project-based learning should be done gradually. For students used to a teacher-centered classroom, the four to six week unit of instruction, which was designed to be predominately student-centered instruction, appears to have been too long. Unless a school is going to adopt problem/project-based learning as the norm for the entire curriculum in some or all of disciplines, shorter introductions to this teaching and learning environment are suggested. As with any new educational practice, support for teachers through professional development is strongly

recommended.

This study also demonstrated that, before expecting students to compare and contrast data sets, they must be very comfortable with the technology they are using. Teacher and student interviews indicated that students, particularly those using the TI-Nspire, were concentrating on mechanics (what buttons to push), not on comparing the data sets. Many of the students in the study had used the TI-84 to enter lists and create scatter plots, but not to create lines of best. This was very different from the experience the students had with the TI-Nspire who had little experience with the calculator prior to the start of the study. By the time the students were comfortable with using the TI-Nspire, the unit was half over and those students failed to do the anticipated in depth analysis of the data sets used in this intervention unit.

The calculator may not have been the only factor affecting the lack of in-depth analysis. The teachers participating in this study felt that the prior academic experience and perhaps, the chronological age of students are two other issues that need to be considered. The teachers indicated that, in their opinion, the students lacked the interest and ability to carry out in depth analysis. However, if this was the students' first experience with problem/project-based learning, then as noted earlier, they may have been overwhelmed by the overall experience. In turn, the teachers may have mistakenly interpreted this lack of preparation for a problem/project-based unit as a lack of interest and ability on the part of the students.

When seeking assent and consent form, it would be beneficial to request all such permissions at the same time. Part of my planned research was to look at the students'

projects. However, because I did not have the second set of assent and consent forms from all members of any group I was not able to do so. First-hand knowledge of the projects would have enhanced the qualitative portion of this study. My class schedule did not permit me to attend the project presentations so I counted on looking at the students' work.

### *Implications for Future Research*

Problem/project-based learning was new to many of the students in this study. The teacher and student interviews seem to indicate that the combination of a new method of instruction and a new calculator at the same time was overwhelming for these students. Future research needs to be done to see whether the problem/project-based learning can be effective for students in urban settings. It appears that students need to be introduced to new methods of instruction more gradually than was done in this study. Start small and work up to a unit covering an entire cluster of instruction. If the targeted population is ninth graders, then ideally they would have experienced some problem/project-based learning in middle school. The unit of instruction should also be separated from the calculator being used. In this study it was not possible to separate the effectiveness of the unit of instruction from the effect of the calculator being used.

Students need to have experience comparing data before they start a unit with as much analysis as contained in this unit of instruction. As the teachers who taught the unit all said, the unit might be more effective if used with juniors or seniors or with students in a Statistics class. Such older students should have had some experience analyzing data and thus should be ready to do the type of in depth analysis required in the Intervention



Curriculum used in this study. Future research using a problem/project-based unit with older students would shed light on whether chronological maturity and academic experience make a difference in a student's ability to critically analyze data sets.

Research should also be done to see whether allowing students to select their own project affects motivation and mastery of the data analysis concepts. Would the unit of instruction be more effective if, rather than being told what type of data they were to find, the groups had made their own selection?

The TI-Nspire notes feature needs to be explored further. Should all of a unit of instruction be on the handheld? Should the students enter the data themselves or does it help to have the data ready for them to use? Does the length of each problem make a difference? If a problem is too long, is it too difficult for students to go back and find specific information? As students become more comfortable with the technological tools and problem/project-based learning, should more of the information be available in electronic format, thus preparing the students to identify their own projects and then locate related data and other information independently? Should only the data be preloaded on the handheld and the problems and related questions be available in print format? Future research on what should be preloaded on the handheld and how to make that information easily accessible to students needs to be explored.

### *Bibliography*

- Armstrong, T. (1994). *Multiple intelligences in the classroom*. Alexandria, Va: Association for Supervision and Curriculum Development.
- Arnold, S. Creating Lessons that Work: the TI-Nspire Challenge! 11. Retrieved from [http://www.sharinginspiration.org/contribs/contrib\\_33/part\\_A/Creating\\_Lessons\\_That\\_Work.pdf](http://www.sharinginspiration.org/contribs/contrib_33/part_A/Creating_Lessons_That_Work.pdf)
- Baldwin, S. (1984). Instruction in spatial skills and its effect on math achievement in the intermediate grades. *Dissertation Abstracts International*, 45(3).
- Barron, B., Schwartz, D., Vye, N., Moore, Petrosino, A., Zech, L., Bransford, J., et al. (1998). Doing with understanding: lessons from research on problem- and project-based learning. *The Journal of the Learning Sciences*, 7(3 and 4), 271-311.
- Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., & Palincsar, A. S. (1991). Motivating project-based learning: sustaining the doing, supporting the learning. *Educational Psychologist*, 26, 369-398.
- Boaler, J. (1998). Open and closed mathematics: student experiences and understandings. *Journal for Research in Mathematics Education (JRME)* 29 (1), 41 – 62
- Boaler, J. (2002). Learning from teaching: exploring the relationship between reform curriculum and equity. *Journal for Research in Mathematics Education*, 33(4), 239-258.
- Bransford, J., Brown, A. L., & Cocking, R. R. (Eds.). (2000). *How people learn: Brain,*

- mind, experience, and school: expanded edition*. Washington, D.C.: National Research Council.
- Chang, K. (2008). Study suggests math teachers scrap balls and slices. *NY Times*. Retrieved from [www.nytimes.com/2008/04/25/science/25math.html](http://www.nytimes.com/2008/04/25/science/25math.html)
- Cohen, D., & Crabtree, B. (2006). Robert Wood Johnson Foundation Qualitative Research Guidelines Project, 2009, from <http://www.qualres.org/HomeTria-3692.html>
- Corsini, R. J. (1998). In R. J. Corsini & B. D. Ozaki (Eds.), *Encyclopedia of Psychology*. New York: John Wiley and Sons.
- David, J. (2008). What research says about project-based learning. *Educational leadership*, 80-82.
- Demana, F., & Waits, B. (1990). Enhancing mathematics teaching and learning through technology. In T. Cooney & C. Hirsch (Eds.), *Teaching and learning mathematics in the 1990's*, pp. 212-222). Reston, Va: National Council of Teachers of Mathematics.
- Dewey, J. (1991). *How we think*. Amherst, NY: Prometheus.
- Dick, T., Burrill, G., & Brady Gill, L. (2007). New technologies offer new ways to engage students. *NCSM Newsletter*, 38(1), 19-21.
- Diehl, A., Grobe, T., Lopez, H., & Cabral, C. (1999). *Project-based learning: a strategy for teaching and learning*. Boston, Ma: Center for Youth development and Education, Corporation for Business, Work and Learning.
- Dillon, J. T., & Wittrock, M. C. (1984). Research on questioning and discussion.

*Educational leadership*, 42(3), 50-56.

DiSessa, A. (1982). Unlearning Aristotelian physics: A study of knowledge-based learning. *Cognitive Science*, 6, 37-75.

Donovan, M. S., Bransford, J. D., & Pellegrino, J. W. (Eds.). (2000). *How people learn: Bridging research and practice*. Washington, DC: National Academy of Science.

Erbas, A., Ledford, S., Polly, D., & Orrill, C. (2004). Engaging students through technology. *Mathematics Teaching in the Middle school*, 9(6).

Erickson, D. (2003). A problem based approach to mathematics instruction. *On Math*, 1(3).

Friel, S. N., Curcio, F., & Bright, G. W. (2001). Making sense of graphs: critical factors influencing comprehension and instructional implications. *Journal for Research in Mathematics Education*, 32(2), 124-158.

Gall, M. (1984). Synthesis of research on teachers' questioning. *Educational Leadership*, 42(3).

Gardner, H. (1999). *The disciplined mind: What students should understand*. New York: Simon and Schuster.

Glatzer, J., & Glatzer, D. J. (2001). *Preparing for the NJ HSPA Grade 11*. New York: Amsco School Publications.

Goos, M. (2004). Learning mathematics in a classroom community of inquiry *Journal for Research in Mathematics Education*, 35(4), 258-291.

Guba, E. G., & Lincoln, Y. S. (1989). *Fourth generation evaluation*. Thousand Oaks, Ca: Sage.

- Gutstein, E. (2003). Teaching and learning mathematics for social justice in an urban, Latino school. *Journal for Research in Mathematics Education*, 34(1), 37-73.
- Harada, V., Kirio, C., & Yamamoto, S. (2008). Project-based learning: Rigor and relevance in high schools. *Library Media Connection*, 14-20.
- Hollebrands, K. (2003). High school students' intuitive understandings of geometric transformations. *Mathematics Teacher*, 97(3), 207-214.
- Hufford-Ackles, K., Fuson, K. C., & Sherin, M. G. (2004). Describing levels and components of a math-talk learning community. *Journal for Research in Mathematics Education*, 35(2), 81-116.
- Hume, D. (1995). *An inquiry concerning human understanding*. Upper Saddle River, NJ: Prentice Hall.
- Janvier, C. (1990). Contextualization and mathematics for all. In T. Corney & C. R. Hirsch (Eds.), *Teaching and Learning mathematics in the 1990s* (pp. 183-193). Reston Va: National Council of Teachers of Mathematics.
- Jones, B. F., Rasmussen, C. M., & Moffitt, M. C. (1997). *Real life problem solving: a collaborative approach to interdisciplinary learning* Washington, D.C.: American Psychological Association.
- Kagan, S. (1994). *Cooperative learning*. San Clemente, CA: Kagan Publishing.
- Katz, V. J. (2007). Algebra: Gateway to a technological future: The Mathematical Association of America.
- Kilpatrick, J., Swafford, J., & Findell, B. (Eds.). (2001). *Adding + it up helping children learn mathematics*. Washington, DC: National Academy Press.

- Koller, O., Baumert, J., & Schnabel, K. (2001). Does it matter? The relationship between academic interest and achievement in mathematics. *Journal for Research in Mathematics Education*, 32(5), 448-470.
- Krajcik, J. S., Blumenfeld, P. C., Marx, R. W., Bass, K. M., Fredricks, J., & Soloway, E. (1998). Inquiry in project-based science classrooms: initial attempts by middle school students. *The Journal of the Learning Sciences*, 7, 313-350.
- Leinwand, S., & Burrill, G. (Eds.). (2001). *Improving mathematics education: resources for decision making*. Washington, DC: National Academy Press
- Marshall, C., & Rossman, G. (1999). *Designing Qualitative Research* (3rd ed.). London: Sage publishers.
- Marx, R. W., Blumenfeld, P. C., Krajcik, J. S., & Soloway, E. (1997). Enacting project-based science: challenges for practice and policy. *Elementary School Journal*, 97, 341-357.
- McGehee, J., & Griffith, L. (2004). Technology enhances student learning across the curriculum. *Mathematics Teaching in the Middle School* 9(6), 344-349.
- Measuring up to the New Jersey core curriculum content standards and success strategies for the HSPA*. (2005). Saddle Brook, NJ: The Peoples Publishing Group, Inc.
- Meyer, D. K., Turner, J. C., & Spencer, C. A. (1997). Challenges in a mathematics classroom: students' motivation and strategies in project-based learning. *The Elementary School Journal*, 97(5), 501-521.
- Moursund, D. (1999). *Project-based learning using information technology*. Eugene, Or:

International Society for Technology in Education.

NCTM. (2000). *Principles and standards for school mathematics*. Reston, Va.: National Council of Teachers of Mathematics.

*New Jersey Core Curriculum Content Standards for Mathematics* (2002).Trenton.

New Jersey HSPA Mathematics Assessment Tutorial. (2010) Retrieved March 27, 2010, 2010, from  
[www.state.nj.us/education/njpep/assessment/hspa/hspa\\_math/index.htm](http://www.state.nj.us/education/njpep/assessment/hspa/hspa_math/index.htm)

Neville, A. (1999). The problem-based learning tutor: teacher? facilitator? evaluator?  
*Medical Teacher*, 21(4), 393-401.

NMAP. (2008). Foundations for success: The final report of the national mathematics advisory panel (pp. 120). Washington, DC: National Mathematics Advisory Panel  
US Department of Education.

Noehrenberg, P. (2004). *Abbott data charts and tables*. Trenton.

Novick, R. (1996). Developmentally appropriate and culturally responsive education:  
Theory in practice. Northwest regional educational laboratory program report  
Retrieved 2/2008, 2008

Peressini, D., Borko, H., Romagnano, L., Knuth, E., & Willis, C. (2004). A conceptual framework for learning to teach secondary mathematics: a situative perspective  
*Educational Studies in Mathematics* (Vol. 56, pp. 67-96): Kluwer Academic Publishers.

Pollak, H. (2007). Mathematical modeling - a conversation with Henry Pollak. In W.  
Blum, P. L. Gabraith, H.-W. Henn & M. Niss (Eds.), *Modeling and applications*

- in mathematics education* (pp. 520). New York, NY: Springer Science and Business Media, LLC.
- Powell, A., & Anderson, C. (2007). Numeracy strategies for African American students: successful partnerships. *Childhood Education*, 84(2), 70-75.
- Rusbult, C. (2008). Aesop's activities: teaching strategies for goal-directed education. Retrieved from <http://www.asa3.org/ASA/education/teach/aesop.htm>
- Scardamalia, M., & Bereiter, C. (2003). Beyond brainstorming: sustained creative work with ideas. *Education Canada*, 43(4).
- Scheaffer, R., & Tabor, J. (2008). Statistics in the high school mathematics curriculum building sound reasoning under uncertain conditions. *Mathematics Teacher*, 102(1), 56-61.
- Schultz, J., & Waters, M. (2000). Why representations. *Mathematics Teacher*, 93(6), 448-453.
- Shifter, D. (1999). Learning geometry: some insights drawn from teacher writing. *Teaching Children Mathematics*, 360-366.
- Shriki, A., & Lavy, I. (2005). *Assimilating innovative learning/teaching approaches into teacher education- why is it so difficult?* Paper presented at the 29th Conference of the international group for the Psychology of Mathematics Education.
- SREB. (2000). Using real-world projects to help students meet high standards in education and the workplace *Site Development Guide #11*. Atlanta Ga: Southern Regional Education Board.
- SRI. (2006). TI-Nspire math and science learning handhelds: What research says and



- what educators can do: Center for Technology in Learning SRI International.
- SRI. (2007). Why should a teacher use technology in his or her classroom? Menlo Park, Ca: Center for Technology in Learning.
- Steen, L. A. (1997). *Why numbers count: Quantitative literacy for tomorrow's America*. New York: College Entrance Examinations Board.
- Steinberg, A. (1998). *Real learning, real work: School-to-work as high school reform*. New York, NY: Routledge.
- Sternberg, R., & Kaufman, J. (1998). Human abilities. *Annual Review of Psychology*, 49, 475-502.
- Strassfeld, B. (1999). Readers exchange: a triangle by any other name. *Teaching children mathematics*, 137.
- Stumbo, C., & Lusi, S. F. (2005). Standards based foundations for mathematics education: standards, curriculum, instruction and assessment in mathematics. Washington DC.
- Sullivan, M. A. (2000). Using real world projects to help students meet high standards in education and the workplace. Site development guide #11. High schools that work. Retrieved from [http://www.eric.ed.gov/ERICWebPortal/custom/portlets/recordDetails/detailmini.jsp?\\_nfpb=true&\\_ERICExtSearch\\_SearchValue\\_0=ED451420&ERICExtSearch\\_SearchType\\_0=no&accno=ED451420](http://www.eric.ed.gov/ERICWebPortal/custom/portlets/recordDetails/detailmini.jsp?_nfpb=true&_ERICExtSearch_SearchValue_0=ED451420&ERICExtSearch_SearchType_0=no&accno=ED451420)
- Tarr, J. E., Reys, R. E., Reys, B. J., Chávez, Ó., Shih, J., & Osterlind, S. J. (1998). The impact of middle-grades mathematics curricula and the classroom learning environment on student achievement. *Journal for Research in Mathematics*

*Education (JRME)* 39 ( 3), 247 - 280

Thomas, J. W. (2000). A review of research on project-based learning. San Rafael, Ca: Autodesk Foundation.

Thomas, J. W., Mergendoller, J. R., & Michaelson, A. (1999). *Project-based learning: a handbook for middle and high school teachers* Novato, Ca: The Buck Institute for Education

Thousand, J., Nevins, V., & Nevins, A. (Eds.). (1994). *Creativity and collaborative learning*. Baltimore, Md: Brookes Press.

Ticha, M., & Hospesova, A. (2006). Qualified pedagogical reflection as a way to improve mathematics education. *Journal of Mathematics Teacher Education*, 9, 129-156.

Toppo, G. (2008, March 13, 2008). A solution to how to teach math: Subtract, *USA Today*.

Twining, J. (1999). *A naturalistic inquiry into the collaboratory: in search of understanding for prospective participants*. Texas Women's University. Retrieved from <http://intertwining.org/dissertation/Chapter1.htm>

Valencia, S., & Peters, C. (1991). You can't have authentic assessment without authentic content. *The Reading Teacher*, 44(8), 590-591.

Wiggins, G. (1993). *Assessing student performance: Exploring the purpose and limits of testing*. San Francisco, CA: Jossey-Bass, Inc.

Yerushalmy, M. (2006). Slower algebra students meet faster tools: solving algebra word problems with graphing software. *Journal for Research in Mathematics Education*, 37(5), 356-387. Appendix A

## Appendix A

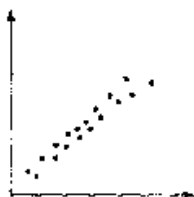
### Pre-test

## Pre-test

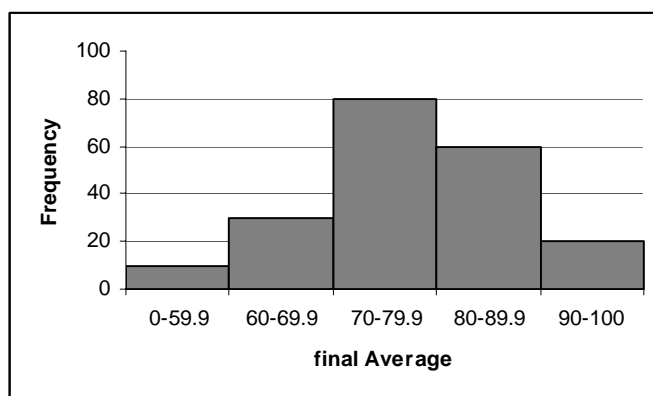
Questions are taken from *Measuring Up to the New Jersey Core Content Standards and Success Strategies for the HSPA* published by Peoples Publishing Group, *Preparing for the New Jersey HSPA Grade 11* published by Amsco and from the NJ Department of Education web site with the permission of all parties

## Data Analysis Pre-test

1. Which of the following could be the equation for the line of best fit for the scatter plot shown?



- A.  $y = 4$       B.  $y = -x$       C.  $y = x$       D.  $x + y = 0$
2. This histogram shows final averages of the students enrolled in Algebra I at the North End High School.



What percent of the students scored B or better in the course?

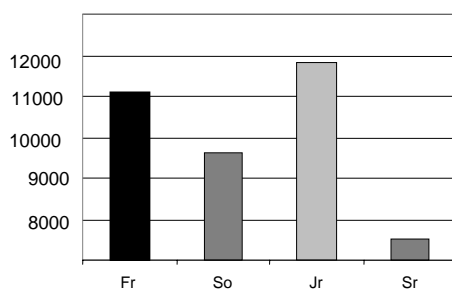
- A. 20%      B. 40%      C. 60%      D. 80%

3. This table shows the amounts of candy sold by the classes in Washington High School.

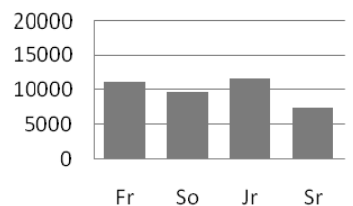
Candy Sale Results	
Freshmen	11,200
Sophomores	9,600
Juniors	11,700
Seniors	7,500

Which graph is the POOREST representation of the data?

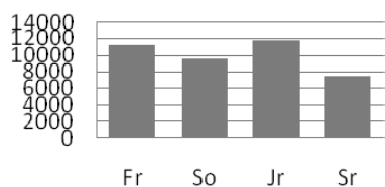
**A.**



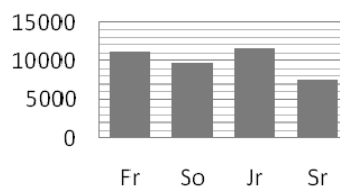
**B.**



**C.**



**D.**



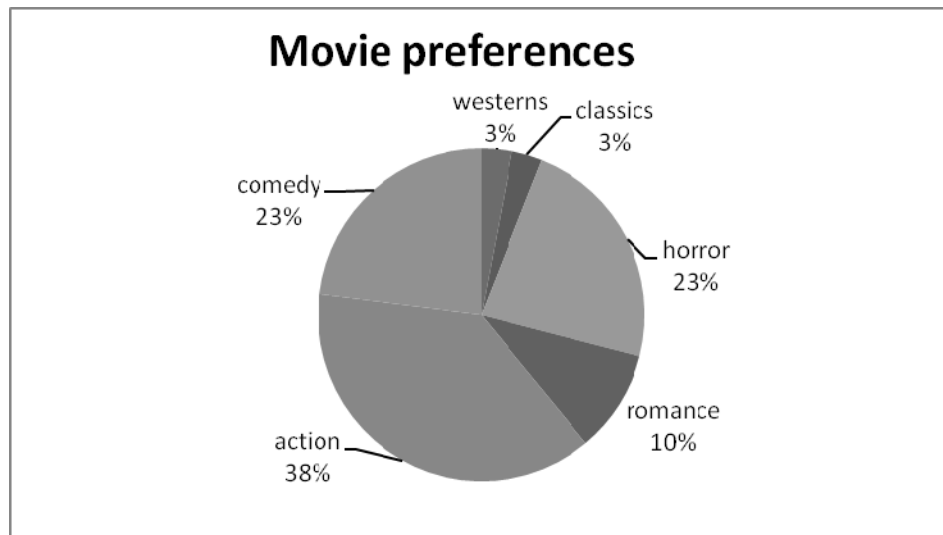
4. For a set of 6 scores, the following can be noted:

Score #1 is 6 points below the mean.  
Score #2 is 10 points below the mean.  
Score#3 is 4 points below the mean.  
Score #4 is equal to the mean

Which of the following could be TRUE about the remaining two scores?

- A. Scores #5 and#6 are both equal to the mean.
- B. Score#5 is 12 points above the mean and Score#6 is 8 points above the mean.
- C. Score#5 is 10 points above the mean and Score#6 is 10 points below the mean.
- D. Score #5 is 20 points above the mean and Score#6 is 4 points above the mean.

5. The 315 members of the Smithfield High School Sophomore class voted to see what kinds of movies the class liked. Their results are below. If they had an “Action Movie Night” fundraiser and sell tickets for \$4 each, approximately how much money should they expect to raise? Assume that the students who like the type of movie will be the only ones in attendance.



- A. \$152.00      B. \$1260,00      C. \$480,00      D. \$580.00
6. David is on the school’s track team. This season, he has run the 400m sprint in the following times: 51.5s, 50.7s, 50.5s 50.7s, 51.0s, and 50.0s. The coach is deciding who is going to run on the state 4 x 400 relay team. What are David’s mean. Median. And mode so far this season?
- A. Mean – 50.73    B. mean – 50.73    C. mean- 51.5    D. mean 50.73
- Median – 50.0    Median – 50.7    Median – 50.7    Median – 50.7
- Mode – 51.5    Mode – 50.0    Mode - 50.7    Mode – 50.7

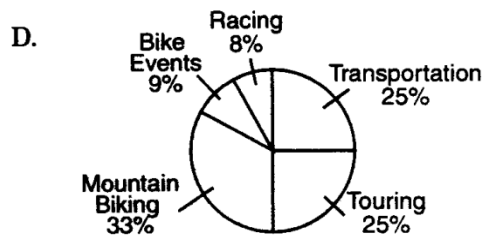
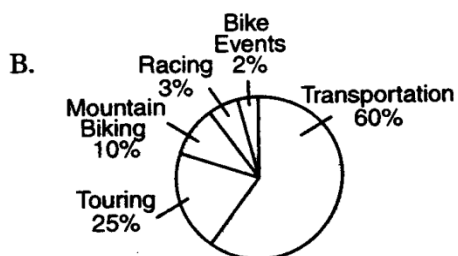
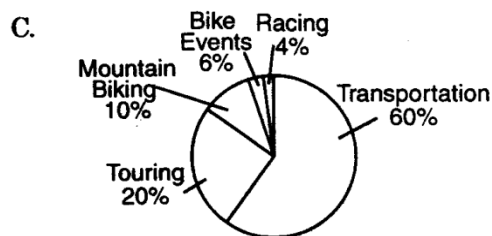
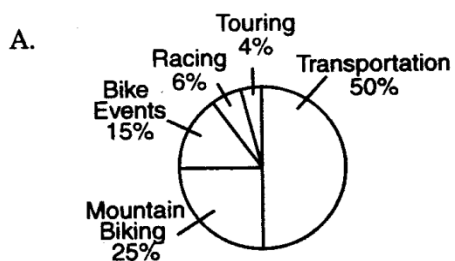
7. Which of the following is the most appropriate time to use a scatter plot?
- A. A scientist measures the amount of bacteria in a Petri dish over a period of time to determine the usefulness of a new medicine.
  - B. The CEO of a large company wants to track his company's financial gains over a 10 year period.
  - C. The US Census wants to find the best way to demonstrate to the public the percentage of US households that own 2 cars.
  - D. Two long-time friends have challenged each other to a public fundraising campaign for the homeless and want to show supporters how well they are doing in their efforts.
8. In the following equation C represents total car rental fee and d represents days rented. What is the slope (m) of this equation?  **$C = 15d + 20$**
- A.  $M = 5$
  - B.  $m = 15$
  - C.  $m = 20$
  - D.  $m = 35$



9. Five hundred bike owners participated in a survey about the kinds of cycling activities they enjoy. The table below shows the results of the survey.

Activity	Number of People
Racing	20
Transportation	300
Bike Events	30
Mountain Biking	50
Touring	100

Which circle graph best represents the data in the table?



10. Herschel took a survey of 100 student athletes at school. He found that 89% favored an increase in the school's athletic budget. Based on this information, Herschel's survey is:

- A. Valid, because the correct sampling methods were used.
- B. not valid, because he did not survey enough students.
- C. Not valid, because the sample was biased.
- D. not valid, because the survey's margin of error was too large.

*Data Analysis Pre-test Open –Ended Questions*

1. The data provided shows test scores for twelve students and the number of hours they studied for the test during the three days prior to taking it.

Hours Studied	1	1.25	1.5	1.75	2	2.25	2.5	2.75	3	3.25	3.5	3.75
Test Score	60	70	68	85	90	98	85	92	91	87	85	72

- Make a scatter plot of this data.
  - Does there appear to be a relationship between a student's test score and the time spent studying? Use the scatter plot to support your answer.
  - Do any of the points appear to be outliers? Explain.
2. Two students in a geometry class made a scatter plot to show the relationship between the diameter and circumference of circular objects. For each object (such as the top of a coffee can), they plotted the points (diameter on the horizontal axis and circumference on the vertical axis) and drew the line of best fit.
- a. Draw a possible scatter plot to go along with this situation.
  - b. What type of correlation did they find? Why does this make sense?
  - c. Explain why you would not expect your data to include any outliers.

3. The table lists the life expectancies in years of males estimated in 1992.

Age in Years	Expected Years Until Death
0	72.2
10	63.1
20	53.4
30	44.2
40	34.9
50	26.1
60	18.2
70	11.8

- Make a scatter plot of the data on graph paper.
- Draw a trend line for the scatter plot.
- Use your trend line to predict the life expectancy of males age 80.

## Appendix B

### Post-test

## Data Analysis Post-test

Directions: **DO NOT WRITE ON THE TEST** Answer the multiple choice questions on the Scantron provided by your teacher. Scrap paper will be provided. Answer the Open-ended questions on the lined paper provided. Show all work on the Open-ended questions.

1. The chart below shows the number of students in a homeroom that voted for each student council candidate.

Paul	
Chris	
Sharla	
Tiko	

If this data were drawn in a circle graph, approximately how many degrees in the central angle of the sector of that circle would represent Tiko's votes?

- A. 22                      B. 68                      C. 79                      D. 90

2. The following data represent morning temperatures for the month of July in Washington, D.C. What are the mean and median of the data?

89 87 85 88 93 93 89 90 91 90 89 88 89 87 90 91 92 92 92 90 89 87 85 86 84 84 83 85 86 88 93
---

- A. Mean 84.3, median 91                      B. Mean 82.9, median 90  
C. Mean 88.5, median 89                      D. Mean 83.9, median 88

3. For which of the following situations would you use the entire population rather than a sample?
- A. A cook making sauce wants to know if there is enough salt in it.
  - B. The president of a company wants to know how many people are going to the company's Holiday Party
  - C. A statistical research company wants to know how many households watched the Academy Awards show.
  - D. A medical research group wants to study the blood cholesterol levels of women in the United States over age 50.
4. Use the given circle graph to determine what percent of Tim's exercise program is devoted to running?



A. 25%

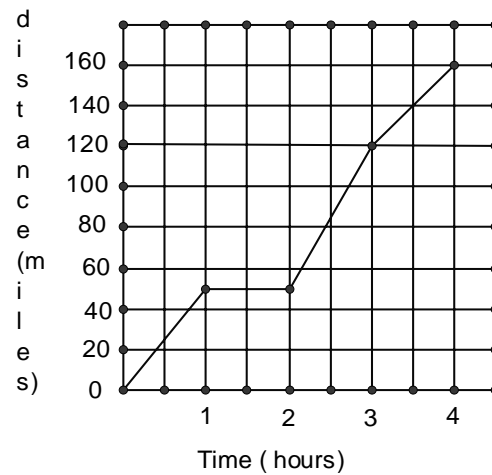
B. 40%

C. 60%

D.  $60\frac{2}{3}\%$

5. The graph shows the distance a car traveled over a 4-hour period of time.

During which interval did the car travel at the fastest rate of speed?



- A. 0 – 1      B. 1 – 2      C. 2 – 3      D. 3 – 4

6. Four of Kira's six biology test scores this semester were: 95, 97, 92, and 87. If the mode for all six scores is 98, what is the mean for all six scores, to the nearest tenth?

- A. 92.8      B. 94.5      C. 95.6      D. 98.0

7. The following table indicates the US Census Bureau's population predictions from 1995 to 2025 (numbers are in millions).

	July1, 1995	July 1, 2000	July 1, 2005	July 1, 2015	July 1, 2025
Delaware	717	768	800	832	861
New Jersey	7,945	8,178	8392	8,924	9,558
New York	18,136	12,202	18,250	18,916	19,830
Pennsylvania	12,202	12,202	12,281	12,449	12,683

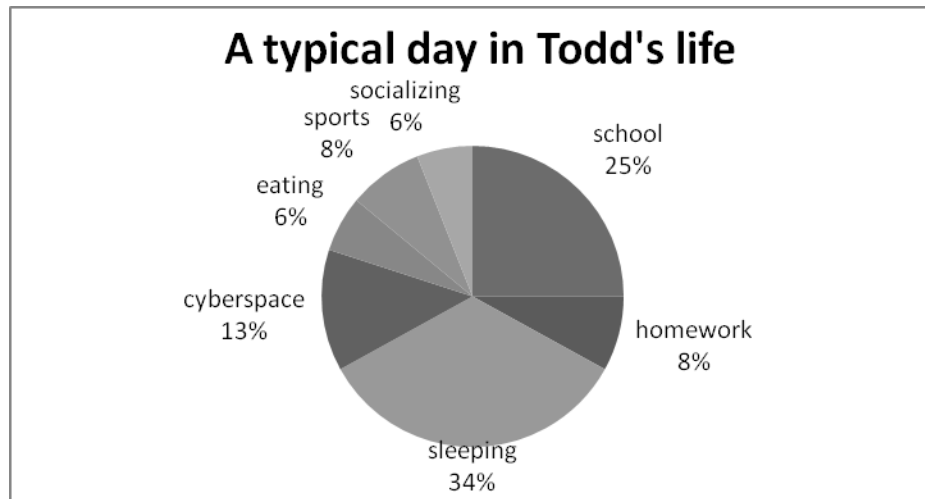
Which state shows the largest percentage growth in population from 1995 to 2025?

- A. Delaware      B. New Jersey      C. New York      D. Pennsylvania



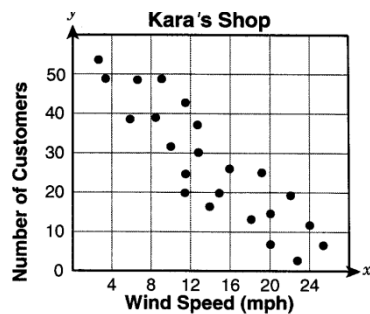
8. The following graph shows how Todd spends his time in the course of a day.

According to this graph, approximately how many hours a day does Todd typically spend doing homework?



- A. 2 hours      B. 3 hours      C. 4 hours      D. 5 hours

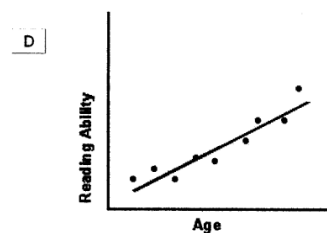
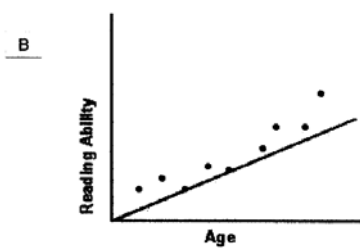
9. Kara's shop rents windsurfing gear at the beach. Each day for a month, Kara recorded the average wind speed and the number of customers each day.



If the wind speed is 12 miles per hour, about how many customers should Kara expect?

- A. 5      B. 20      C. 35      D. 50

10. A study recently resulted in the results shown below. Based on the data for the chart below, which choice would best help predict a reading ability at a certain age?



## Data Analysis Post-test Open-ended Questions

1. New Jersey's population,  $p$  (in millions), from 1900 to 1990 is shown in the table below.

Year ( $t$ )	Population ( $p$ ) (in millions)
1900	1.9
1910	2.5
1920	3.2
1930	4.0
1940	4.2
1950	4.8
1960	6.1
1970	7.2
1980	7.4
1990	7.7

Sketch a scatter plot. Let  $t = 0$  represent 1900. Label your graph with the approximate values for time and population.

Using your scatter plot, what type of correlation/relationship do  $p$  and  $t$  have?

Using the scatter plot, predict what the population of New Jersey will be in the year 2000. Explain the strategy you used to make that prediction.

2. Miguel's scores in chemistry this quarter are 90, 30, 78, 75, 40, 54 and 70.

He decided to use the median grade to report his grade in chemistry to his parents. What advantage is there to his using the median rather than the mean or the mode?

3. Study the information in each of the following charts

Chart 1 : SURVEY OF SPORTS

SPORT	JOHN'S CLASS	PAT'S CLASS
BASEBALL	14	46
BASKETBALL	13	19
BOWLING	34	40
FOOTBALL	15	50
GOLF	14	53
HOCKEY	7	23
TENNIS	3	19

Chart 2: KYLE'S EXPENSES BASED ON 4000 MONTHLY SALARY

RENT	20%
ENTERTAINMENT	15%
SAVINGS	30%
FOOD	10%
CLOTHING	10%
UTILITIES	2.5%
CAR & INSURANCE	12.5%

Chart 3:BOB’S ANNUAL SALARY AND SAVINGS FOR THE LAST 10 YEARS

YEAR	SALARY	SAVINGS
1990	35,000	5,250
1991	40,000	6,000
1992	45,000	6,750
1993	50,000	7,500
1994	55,000	8,250
1995	60,000	9000
1996	65,000	13,000
1997	70,000	14,000
1998	80,000	16,000
1999	90,000	18,000

Based on the different sets of data displayed by each of the charts, describe the type of graph that should be used to display each set of data. Explain why you selected each type of graph.

Questions are taken from Measuring Up to the New Jersey Core Content Standards and Success Strategies for the HSPA published by Peoples Publishing Group, Preparing for the New Jersey HSPA Grade 11 published by Amsco and from the NJ Department of Education web site with the permission of all parties

## Appendix C

### Attitudinal Survey

### Student Attitudinal Survey

#### Student Information

Name \_\_\_\_\_ ID \_\_\_\_\_

Gender        \_\_\_\_\_ M        \_\_\_\_\_ F

Race (Optional) \_\_\_\_\_ American Indian of Alaska Native

\_\_\_\_\_ Black or African American

\_\_\_\_\_ Native Hawaiian of Other Pacific Islander

\_\_\_\_\_ White

Ethnicity        \_\_\_\_\_ Hispanic or Latino

\_\_\_\_\_ Not Hispanic or Latino

Is English your first language?    \_\_\_\_\_ Yes    \_\_\_\_\_ No

		Strongly Disagree	Disagree	Agree	Strongly Agree
1	I like solving Open-ended questions				
2	I like to do homework on Open-ended questions				
3	I need help with Open-ended questions				
4	I can read but I do not understand Open-ended questions				

		Strongly Disagree	Disagree	Agree	Strongly Agree
5	I find it difficult to participate when we are doing Open-ended questions				
6	Teachers explain Open-ended questions very well				
7	I usually understand the text or story in Open-ended questions				
8	Open-ended questions take me quite a long time to do				
9	I like to see examples of Open-ended questions from outside the text-book, in the real world, to see how we use math				
10	I am good at working with percents				
11	I am good at interpreting graphs				
12	I am good at interpreting tables				
13	I am good at creating graphs from data				
14	I am good at finding a line of best fit				
15	I am good at drawing conclusions from graphs				



		Strongly Disagree	Disagree	Agree	Strongly Agree
16	I am good at drawing conclusions from tables				
17	I am good at modeling situations using graphs and tables				
18	I am good at making scatter plots				
19	I am good at finding outliers				
20	I am good at finding the mean of a set of data				
21	I am good at finding the median of a set of data				
22	I am good at finding the mode of a set of data				
23	I am good at finding the range of a set of data				
24	I am good at drawing histograms				
25	I am good at drawing scatter plots				

		Strongly Disagree	Disagree	Agree	Strongly Agree
26	I am good at drawing bar graphs				
27	I am good at drawing circle graphs				
28	I am good at drawing line graphs				
29	I am good at deciding if a sample is biased or unbiased				
30	I am good at analyzing data to make predictions				
31	I am good at selecting an appropriate measure of central tendency to best describe data				
32	I am good at evaluating arguments based on an analysis of data				
33	I understand math				
34	I am good at interpreting histograms				
35	I am good at interpreting scatter plots				
36	I am good at interpreting bar graphs				
37	I am good at interpreting circle graphs				

38	I am good at interpreting line graphs				
		Strongly Disagree	Disagree	Agree	Strongly Agree
39	I am good at drawing a line of best fit				
40	I am good at predicting from a line of best fit				

## Appendix D

### Semi-structured Interview Protocols

#### Student Interview Protocol

#### Teacher Interview protocol

Principal Investigator: Joy Brokes

### **Semi-structured Student Interview Protocol**

Thank you for joining this interview. I will ask you few questions about your experience with data analysis and using the TI-Nspire. The interview will take about 20 minutes. Your responses are voluntary. You may or may not answer any, or part of any, question. You may stop any time you want. However, I may interrupt you after a question and go to the next question in order to finish the interview on time.

Your responses will be very helpful in determining how we can help our students do better when working with data analysis problems. In order to facilitate the correct interpretation of your responses, I will write notes as well as audiotape your responses. Only I will have access to my notes and this tape. This tape will be destroyed after it is transcribed. Your responses may be used in my dissertation. However, your identity will be kept confidential. Your name may be published only with both your and your parent's written consent.

### **Questions for the Post-intervention Interviews**

**(Questions to determine attitude toward project-based learning and using the TI-Nspire, especially the document features)**

- 1) Name the **one** area of data analysis that you understand the best.
- 2) Are there other areas of data analysis that you understand?
- 3) If yes, which areas do you feel this project helped you understand.
- 4) What do you like about data analysis? Why?

- A. Scatter plots
- B. Pie charts
- C. Comparing and Contrasting Data
- D. Other

5) What do you **not** like about data analysis? Why?

- A. Scatter plots
- B. Pie charts
- C. Comparing and Contrasting Data
- D. Other

6) Did having all of your work in one place on the TI-Nspire help you during the project?

7)How?

Staying organized? Referring back to previous work? Being able to write notes?

Getting feedback on questions from the teacher on your calculator?

8) What did you like about the mathematics in the lessons during the last 4 weeks?

9) What did you like or dislike about how the lessons were taught during the last 4 weeks?

10) Did the lessons during the last 4 weeks help you take the posttest? Yes or No?

11) Ask for specifics to support a yes or no answers to # 10.

12)What is the importance of data analysis on exams?

(Provide the interviewee with some lead, like Open-ended questions)

13) Ask for specifics to support a yes or no answers to # 12

(If necessary provide a prompt such: Did having all the data available in one place help? Did in depth study help you understand interpreting graphs?

14) What exactly was the difference between the way you approached interpreting data in the past and the way you learned to do it during the last 4 weeks?

15) Did the lessons during the last 4 weeks affect your interest in analyzing data?  
Yes or No?

16) Ask for specifics to support a yes or no answers to # 15

17) What do you say to other students about the types of projects you did in the past 4 weeks?

Thank you for your participation and your input. This will be very helpful to me.

### **Semi-structured Teacher Interview Protocol**

Thank you for joining this interview. I will ask you a few questions about your experience in teaching a problem-project based unit using the TI-Nspire. The interview will take about 20 minutes. Your responses are voluntary. You may or may not answer any question or part of a question. You may stop any time you want. I may interrupt you after any question and go to the next question in order to finish the interview on time or ask another question for clarification.

Your responses are very helpful in determining how we can best help our students do better on the HSPA. In order to facilitate correct interpretation of your responses, I will write notes as well as audiotape your responses. Only I will have access to my notes and this tape. This tape will be destroyed 1 year after my dissertation is finished. Your responses will be used in my dissertation. However, your identity will be kept confidential. Your name may be published only after your written consent, otherwise I will use a pseudonym or code.

### **Questions for Post-intervention Interview**

**(Questions to determine the effects of teacher training and the instructional intervention)**

- 1) How did you feel about using a problem/project-based unit of instruction?
- 2) Did you see a difference in your students' attitude towards learning during the unit?
- 3) If so, what kind of changes did you notice?
- 4) Do you feel that the document features of the calculator helped your students?



- 5) If so, how?
- 6) Has your experience with this project changed your opinion about teaching the old way (using the standard curriculum) versus project type units?
- 7) Has your experience changed your attitude about how a handheld can be used in a classroom?
- 8) Do you feel that your students have a better understanding of data analysis as a result of the in depth study. (Do you think that it will save us re-teaching time in future courses?)
- 9) Do you feel that we should consider creating problem/project-based units for other areas of the HSPA, or for other courses?

Thank you for your participation and your input. This will be very helpful to me.

## Appendix E

### Calculator descriptions

TI-Nspire

TI-84

## Description of the TI-Nspire

### Multiple Representations

The power of visualization – multiplied on a single screen.

**With TI-Nspire™ and TI-Nspire CAS technology, educators and students can see multiple representations of a problem – algebraic, graphical, geometric, numeric and written – on a single screen. Explore individual representations, one at a time, or as many as four all on the same screen.**

**Choose different split-screen options.** Using a drop-down menu, select the number of representations and their arrangement on screen.

**Representations can be dynamically linked.** This means that changes made to one representation of a problem are automatically reflected in other representations of the same problem – instantly, in real time, on the same screen. The dynamic linking of multiple representations provides real-time, interactive feedback so students can try different problem-solving techniques.

Research shows that students learn mathematical concepts more readily and with deeper understanding when they learn across different forms of representation. When they are able to see the math in different ways – through multiple representations – they begin to broaden their critical thinking skills and make meaningful connections.

**This unique ability to see and explore multiple representations on a single screen is supported by the following applications built into both the TI-Nspire handhelds and TI-Nspire software:**

**A CALCULATOR supporting algebraic representations**

Perform computations. Enter and view expressions, equations and formulas exactly as they appear in math textbooks. Quickly and easily select the proper syntax, symbols and variables from a template that supports standard mathematical notation. Scroll through previous entries to explore outcomes and patterns.

**B GRAPHS & GEOMETRY supporting graphical and geometric representations**

Graph equations, expressions and other functions. Then make changes to variables to see how the values in dynamically linked tables and equations will also change, in real time. Add labels, rename the axes and include text on the graph's coordinate plane. Construct and explore geometric figures interactively and create animations. Integrate graphing and geometry on the same screen to help reveal connections between concepts in algebra and geometry.

**C LISTS & SPREADSHEET supporting numeric and analytical representations**

Capture and track the values of a graph and collected data, and observe number patterns. Organize the results of statistical analysis. Experience capabilities similar to using computer spreadsheets: label columns, insert formulas into cells, select individual cells and change their size, and more.

**D NOTES supporting written representations**

Put the math in writing. Include the word problem with its solutions. Explain problem-solving approaches - right in the handheld or computer software. Question-

and-answer templates allow educators to prompt students to document their steps and progress.

#### Data and Statistics

##### **Gather the information to tell a story – one point at a time**

**This built-in application allows educators to input and organize statistical data, using different graphical representations on a single screen to guide students in hypothesizing results and making meaningful connections.**

The Data and Statistics application - exclusive to TI-Nspire™ technology and with

**TI-Nspire CAS** technology – is available with the **latest handheld operating system download**

- Summarize statistical data using different graphical methods
- Experience **list and spreadsheet features** similar to computer software features.
- Manipulate and explore data - watch how **dynamic changes in data** changes can affect the statistical analysis
- Create “quick graphs” of one-variable and two-variable data sets
- Perform a variety of descriptive and inferential statistical calculations on real data sets, while simultaneously analyzing graphical representations

##### **Additional Data and Statistics functionality:**

- Scatter plots
- x-y line
- Histogram

- Box plots
- Regression lines
- Normal probability plots
- Hypothesis test plots

### Save and Review Work

Follow every problem-solving step by every student.

The unique features of TI-Nspire™ and TI-Nspire CAS technology include the ability to create, edit, save and review problem solving in electronic documents similar to the word processing and file storage features of a computer.

The ability to save and review assignments as electronic documents allows students to show their work step-by-step and demonstrate problem-solving techniques. Educators are able to effectively assess critical thinking and guide individual progress.

- Class assignments and homework documents can be saved on TI-Nspire/TI-Nspire
- CAS handhelds and computer software.
- Students are able to pick up where they left off in a previous class.
- Students can continue work on projects outside of class, easily transferring documents between their handheld and computer.
- TEACHING WITH TI-NSPIRE DOCUMENTS
- TI-Nspire and TI-Nspire CAS technology's use of documents aligns with teaching
- practices proven to enhance learning.
- Save and continue work from one class to the next

- Allow students to reflect on their work and make revisions.
- Organize the build-up and sequencing of ideas
- Conduct formative assessment of student understanding
- Prepare and save activities and other materials before class.

(Note: Description is from Texas Instruments [education.ti.com](http://education.ti.com) webpage)

## TI-84 Description

### Features Summary

The TI-84 Plus Silver Edition graphing calculator comes with a USB cable, plenty of storage and operating memory, and lots of pre-loaded software applications (Apps) -- all to help you gain an academic edge from pre-algebra through calculus, as well as biology, chemistry and physics.



Count on TI calculators at exam time. You can use this TI graphing calculator on the PSAT, SAT, and ACT college entrance exams and AP tests.\*

### Key features:

- Nine times the memory of the TI-83 Plus (stores up to 94 Apps)
- More than twice the speed of the TI-83 Plus
- USB cable included with purchase for downloading free Apps and games
- Preloaded Periodic Table and Organizer software applications
- Customizable color faceplates (available separately)
- Customizable GraphiTI slide case stickers (available for a limited time)
- One-year limited manufacturer's warranty

### New App makes entering easier

You can now see and enter math problems in your TI graphing calculator just like they appear in your textbooks. Download the free Zoom Math Starter Edition™ - App4Math™ App by I.Q. Joe to your TI-83 Plus or TI-84 Plus family calculator.



FREE! test prep practice questions

TI and The Princeton Review® have come together to provide students with a complete college preparation resource. Download free SAT or ACT questions on your TI graphing calculator and get test-ready to perform your best.

Find what you need

TI graphing calculators are learning tools designed to help students visualize concepts and make connections in math and science. Take a look at the TI Calculator Comparison Chart to find which model fits your needs.

(Note: Description is from Texas Instruments education.ti.com webpage)

## Appendix F

### Transcripts of Intervention Unit of Instruction

Transcript for Intervention Unit of Instruction for the TI-Nspire

Answers to Questions in Curriculum

Rubric for Grading Projects

Transcript of the Data analysis Unit of Instruction for the TI-84

# Transcript of Intervention Unit of Instruction for the TI-Nspire

(Page # on calculator) **1.1** We will start our exploration by looking at population data for the USA, NJ, Passaic County and Paterson. Because some people consider themselves more than one ethnicity, numbers have been slightly adjusted when necessary. Data is for the year 1996 and is divided by ethnicity and gender. The first set of data is for the USA

**1.2** Data for the US and NJ are reported in 1,000,000's

Data for Passaic County and Paterson are reported in 1,000's

When you have finished reading, analyzing or answering the questions on a given page go to the next page.

**1.3** The first set of data is the population of the United States in 1996. Remember, the data is rounded to the nearest 100,000 and is reported in 100,000,000's.

	A ethnicity	B uspop	C	D
1	white	198.8		
2	black	38.2		
3	asian	13.2		
4	hispanic	44.3		
5	other	4.9		
6				

1.4 A1 ="white "

**1.5**

1. What was the approximate population of the United States in 1996? Round your answer to the nearest 100,000.

2. How many White people were there?
3. The number of Blacks is what fraction of the number of Whites?
4. The number of Hispanics is what fraction of the number of Whites?
5. The number of Blacks is what fraction of the number of Hispanics?

**1.6** On the next page, you will find another copy of the spreadsheet of US population in 1996. If the population of the United States was about 299.4 million, find the percent of people in each ethnic group. Call column C “uspercent” (the “ marks are not part of the name) and enter the data on the next page. Round the percents off to the nearest integer. (feel free to add a calculator page if you want to)

Then, in column D, which you will name “usfreq”, high-light the line right under your column name (the gray line) and go to the catalog to find “freqTable”. Your handheld will say “=freqTable►list” and you will add “(ethnicity,uspercent)”

After you have added the two columns, go to the page after the spreadsheet

**1.7** Your finished spreadsheet looks like this, except that on the handheld all the words White, Black, etc. are in one column. I have moved them to save space.

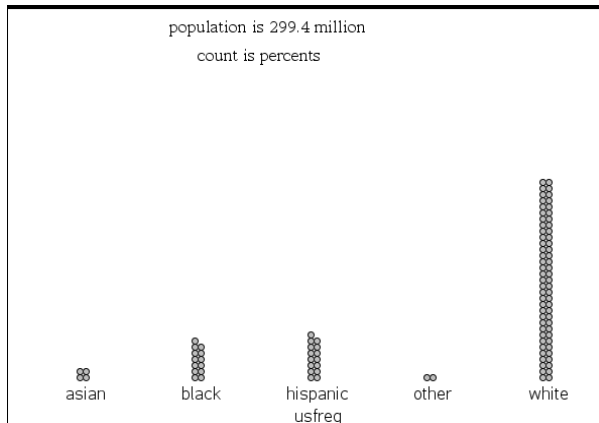
Column A	Column B	Column C	Column D				
ethnicity	uspop	uspercent	usfreq	continuation of column D			
White	198.8	66	White	White	White	White	Asian

Black	38.2	13	White	White	White	White	Asian
Asian	13.2	4	White	White	White	White	Asian
Hispanic	44.3	15	White	White	White	White	Hispanic
Other	4.9	2	White	White	White	White	Hispanic
			White	White	White	White	Hispanic
			White	White	White	Black	Hispanic
			White	White	White	Black	Hispanic
			White	White	White	Black	Hispanic
			White	White	White	Black	Hispanic
			White	White	White	Black	Hispanic
			White	White	White	Black	Hispanic
			White	White	White	Black	Hispanic
			White	White	White	Black	Hispanic
			White	White	White	Black	Hispanic
			White	White	White	Black	Hispanic
			White	White	White	Black	Hispanic
			White	White	White	Black	Other
			White	White	White	Asian	Other

### 1.8 Insert a data and statistics page



The inserted page will look like this



**1.9** Look at the USfreq column of the spreadsheet.

6. Compare that column with the dot plot. That is what a frequency list does.

Now, look at the dot chart and answer the following questions.

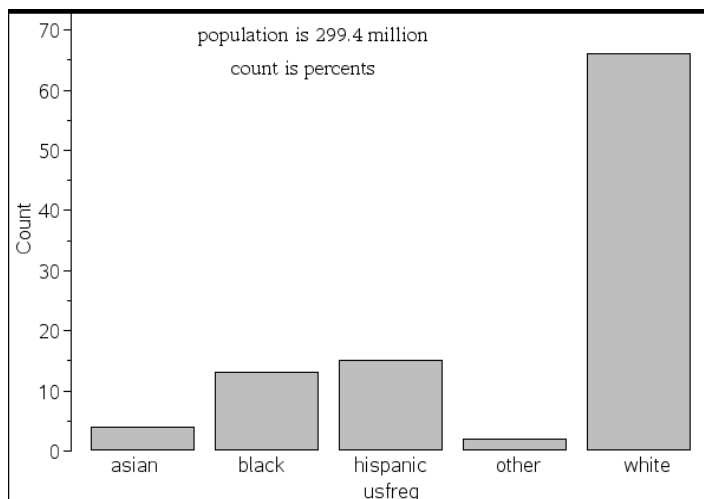
7. What does each dot represent?

8. If you combined the Asian, Black, Hispanic, and Other categories, how would it compare to the White population?

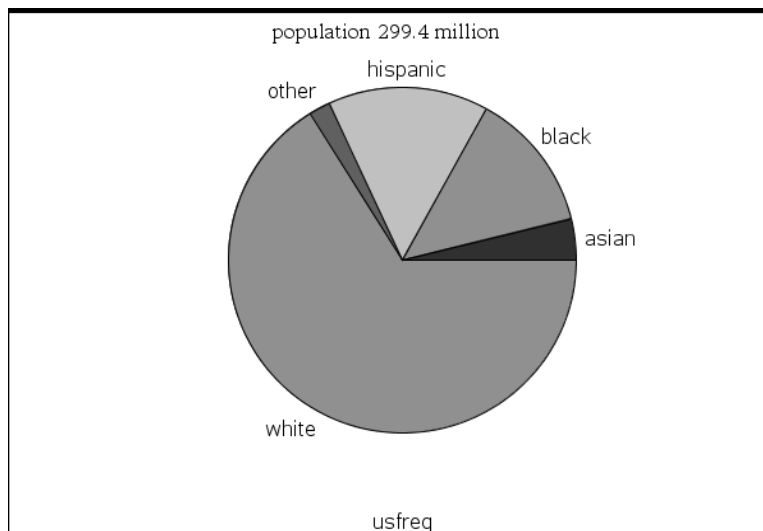
**1.10** Go back a page and select bar chart. Pay attention to the dots as the bar chart is formed.

9. What does the count represent?

New view of inserted page



**1.11** Go back to the bar chart and select pie chart. Pay attention to the dots as the pie chart is formed. Add a text box saying the “Population is 299.4 Million”



**1.12**

10. What did you notice about the bar graph as the pie chart was formed?

11. Do the pieces in the pie seem to agree with the percents in the spreadsheet? Why or



why not?

12. Do the percents add up to 100? why or why not?

**1.13** The next set of data is NJ. The population in 1996 was about 8.7 million.

The data is reported to the nearest 1,000,000 and is rounded to the nearest 100,000.

	A ethnic...	B njpop	C	D
1	white	5.4		
2	black	1.3		
3	asian	0.6		
4	hispanic	1.2		
5	other	0.2		
6				
1.14	A1 ="white "			

**1.15**

13. Which ethnicity has the highest population in New Jersey? How many people are in that group?

14. Is this the same group as the US population?

15. Have the rankings of any groups changed?

**1.16** On the next page, you will find another copy of the NJ spreadsheet

If the population of New Jersey in 1996 was about 8.7 million, find the percent of people in each ethnic group. Call column C “njpercent” and enter the data on the next page.

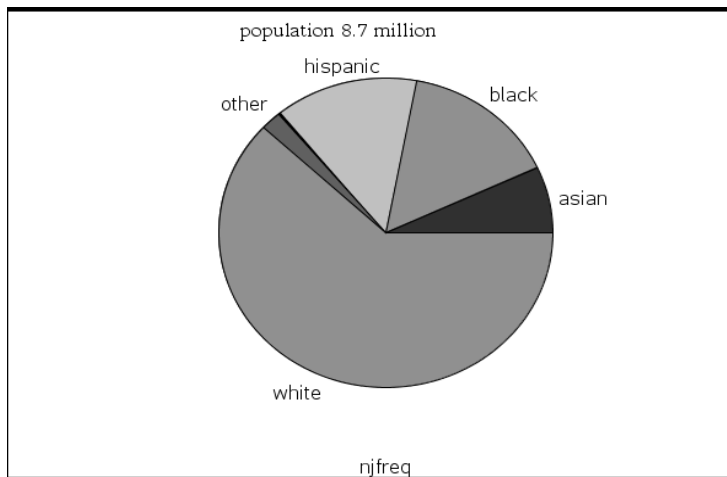
**Note: Depending on the level of the class, the students can develop a formula to calculate the data. That formula goes on the grey line under the title uspercent. The formula is  $njpercent=round(100*njpercent/8.7,0)$**

[illegible]

			White	White	White	Black	Hispanic
			White	White	White	Black	Hispanic
			White	White	White	Black	Hispanic
			White	White	White	Black	Hispanic
			White	White	White	Asian	Hispanic
			White	White	White	Asian	Other
			White	White	White	Asian	Other

**1.18** Insert a data and statistics page. Move your cursor to the bottom center and when asked Click to add variable click and choose “njfreq”. Next change to a bar chart and then to a pie chart Add a text box “Population 8.7 Million”

Added page



**1.19** Compare the pie chart for the US and the one for NJ.

16. What sectors of the pie chart are about the same size in both charts and which ones have changed?

### 1.20 The next set of data is Passaic County

The population of Passaic County in 1996 was about 489.1 thousand.

The data this time is given in percents, rounded to the nearest integer.

	A ethnicity	B pcperc...	C	D	E	F	G
1	white	48					
2	black	15					
3	asian	5					
4	hispanic	31					
5	other	1					
6							
7							
8							
9							
10							
11							
12							

1.21 A1 ="white"

### 1.22 On the next page, you will find another copy of the Passaic County spreadsheet

If the population of Passaic County in 1996 was about 489.1 thousand, find the number of people in each ethnic group. Call column C “pcpop” and enter the data on the next page. Enter the data (in thousands), rounded to the nearest 100. Feel free to add a calculator page.

**Note: Formula**  $=\text{round}(497.1*\text{pcpercent}/100,1)$

Then, in column D , which you will name “pcfreq”, high-light the line right under your column name (the gray line) and write “=freqTable►list(ethnicity,pcpercent)” Note: You can find the command “freqTable” in the catalog ( the book)

After you have added columns “pcpop” and “pcfreq” go to the page after the spreadsheet



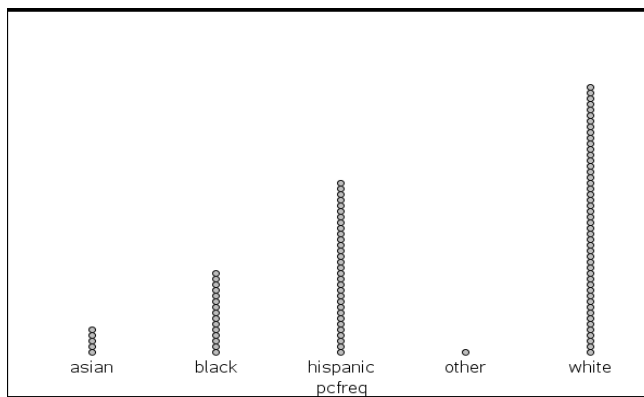
			White	White	Black	Hispanic	Hispanic
			White	White	Black	Hispanic	Hispanic
			White	White	Black	Hispanic	Other

**1.24** 17. How do the percents of each ethnicity in Passaic County compare with the US and NJ?

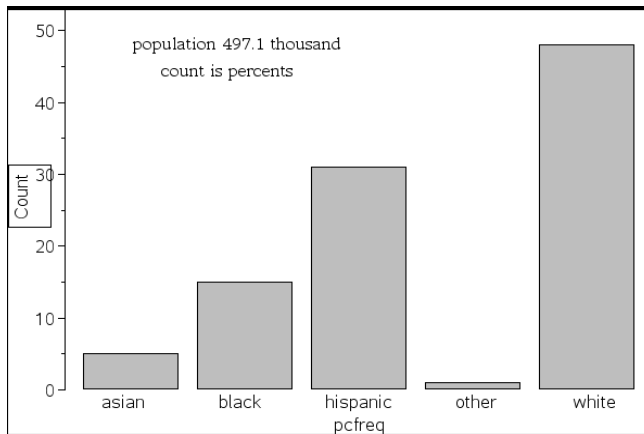
**1.25** Insert a data and statistics page. Move your cursor to the bottom center and when asked Click to add variable click and choose “pcfreq”. Next change to a bar chart

Add a text box “population 489.1thousand.”

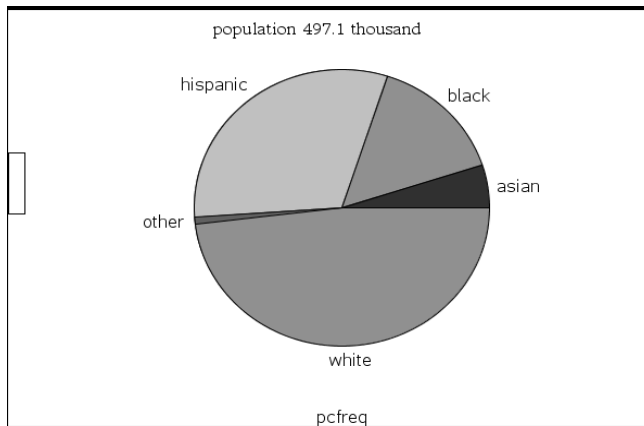
Added page before change to bar chart



Added page as a bar chart



Added page as a pie chart



### 1.26

18. What did you notice about the pieces of the pie? (Are the pieces for each ethnicity the same size as the pieces were in the country and state pie charts)?

19. If not, which pieces are bigger and which are smaller? Why?

**1.27** The next set of data is for Paterson, NJ.

The population of Paterson in 1996 was about 148.7 thousand.

The data is in percents, rounded to the nearest integer.

	A ethnicity	B patper...	C	D	E	F	G
1	white	26					
2	black	28					
3	asian	2					
4	hispanic	43					
5	other	1					
6							
7							
8							
9							
10							
11							
12							
1.28	A1	="white"					

**1.29**

20. Which ethnicity has the largest population?

21. Is this the same as for the USA, NJ and Passaic County?

**1.30** On the next page, you will find another copy of the Paterson spreadsheet

If the population of Paterson in 1996 was about 148.7 thousand, find the number of people in each ethnic group. Enter the data (in thousands), rounded to the nearest 100.

Feel free to add a calculator page. Call column C “patpop” and enter the data on the next page

Then, in column D , which you will name “patfreq”, highlight the line right under your column name (the gray line) and write “=freqTable►list(ethnicity,patpercent)” Note: Do this like you did before.

After you have added columns “patpop” and “patfreq”, go to the next page after the spreadsheet

**1.31** after completion

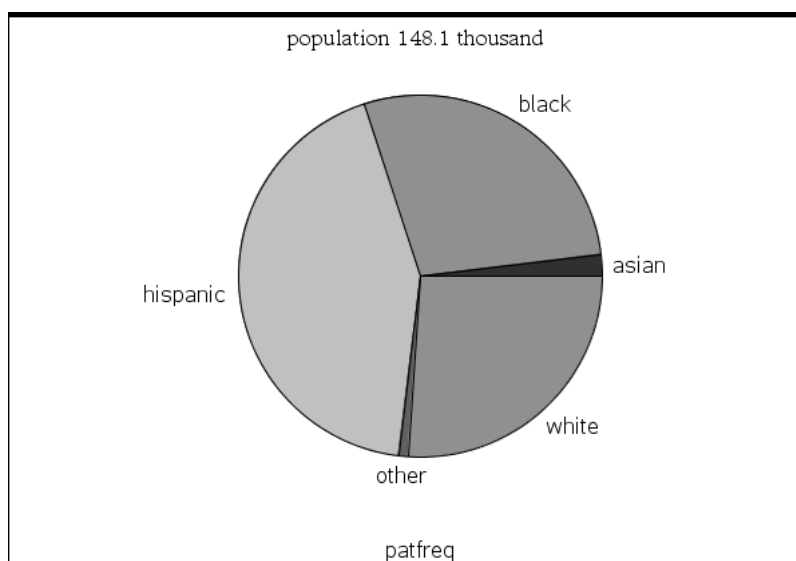


ColumnA	ColumnB	ColumnD	ColumnD				
ethnicity	Patpercent	patpop	patfreq	continuation of column D			
White	26	38.7	White	White	Black	Hispanic	Hispanic
Black	28	41.6	White	White	Black	Hispanic	Hispanic
Asian	2	3.3	White	White	Black	Hispanic	Hispanic
Hispanic	43	63.9	White	White	Black	Hispanic	Hispanic
Other	1	1.5	White	White	Black	Hispanic	Hispanic
			White	White	Black	Hispanic	Hispanic
			White	Black	Black	Hispanic	Hispanic
			White	Black	Black	Hispanic	Hispanic
			White	Black	Black	Hispanic	Hispanic
			White	Black	Black	Hispanic	Hispanic
			White	Black	Black	Hispanic	Hispanic
			White	Black	Black	Hispanic	Hispanic
			White	Black	Black	Hispanic	Hispanic
			White	Black	Black	Hispanic	Hispanic
			White	Black	Asian	Hispanic	Hispanic
			White	Black	Asian	Hispanic	Hispanic
			White	Black	Hispanic	Hispanic	Hispanic
			White	Black	Hispanic	Hispanic	Hispanic
			White	Black	Hispanic	Hispanic	Hispanic

			White	Black	Hispanic	Hispanic	Other
--	--	--	-------	-------	----------	----------	-------

**1.32** Insert a data and statistics page. Move your cursor to the bottom center and when asked “Click to add variable”, press enter and choose “patfreq”. Next select pie chart. Add a text box “population 148.7 thousand”.

Added page



### 1.33


22. What is different about Paterson's population?

23. What observations can you make comparing the spreadsheets, dot charts, bar charts and pie charts for the US, NJ, Passaic County and Paterson

Problem 2

**2.1** The next problem is a comparison of median wages for 16-24 year old full time workers, broken down by ethnicity

Statistics are from the Bureau of Labor and Statistics

<b>Question</b>
1. What does median income mean? 2. Why does the Bureau of Labor and Statistics use the median and not the mean or mode?
<b>Answer</b> 
1. 2.

**2.2**

**2.3** As you start the next problem you will see data for workers of all ethnicities combined. The data is divided by gender, age and ethnicity.

When you have finished reading, analyzing or answering the questions on a given page go to the next page. In this set of problems you will be looking at weekly wages for workers.

**3.1** In every scatter plot the

· is both men and women

° is men

x is women

In all of the spreadsheets and scatter plots the year 2000 is indicated as year 0, 2001 is 1, etc.

Look at the data and answer the questions on the next 2 pages.

3.2

3.2

### Median Income

	A	B	C	D	E	F	G
	year	all	allmen	allwo...			
1	0	353	373	332			
2	1	373	391	348			
3	2	377	398	355			
4	3	380	391	366			
5	4	387	397	370			
6	5	393	407	374			
7	6	410	421	395			
8	7	421	436	404			
9	8	447	469	415			
10							
11							
12							
3.2	E9:E10	0					


#### Question

3. State 5 observations about the data in the table.

#### Answer

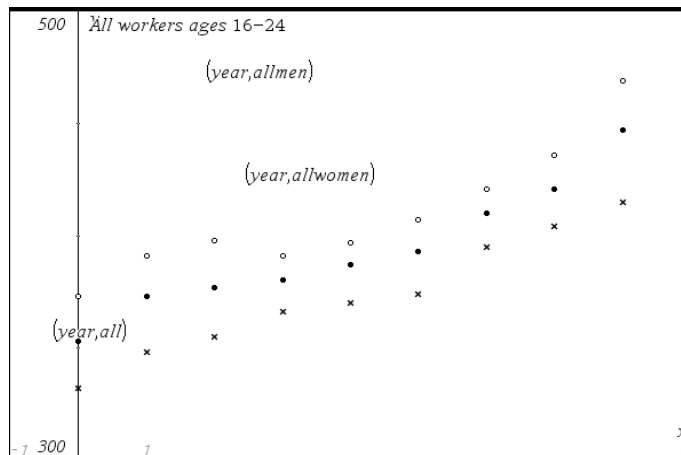
- 1.
- 2.
- 3.
- 4.
- 5.

3.3

<b>Question</b>
4. What questions do your observations bring to mind?
<b>Answer</b> 

3.4

3.5 On the next page you will see a scatter plot of the data from the spreadsheet.



3.6

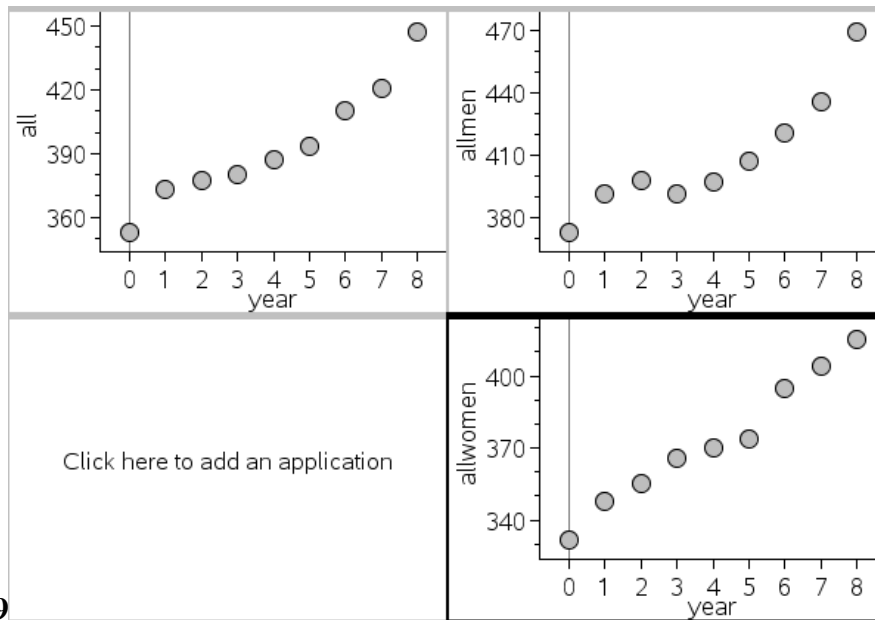
3.7

5. What do the tick marks on the scatter plot on page 3.6 stand for? You might need to look at the window settings to answer this.

6. What is the range of wages in the first set of data for men, women and all workers?

3.8 Next we will look at lines of best fit for all workers

The next page has 3 data analysis pages and a blank page. select “year” as the horizontal axis and “all” as the vertical axis for one tab to the next one and select “year” and “allmen” and on the third “year” and “allwomen”

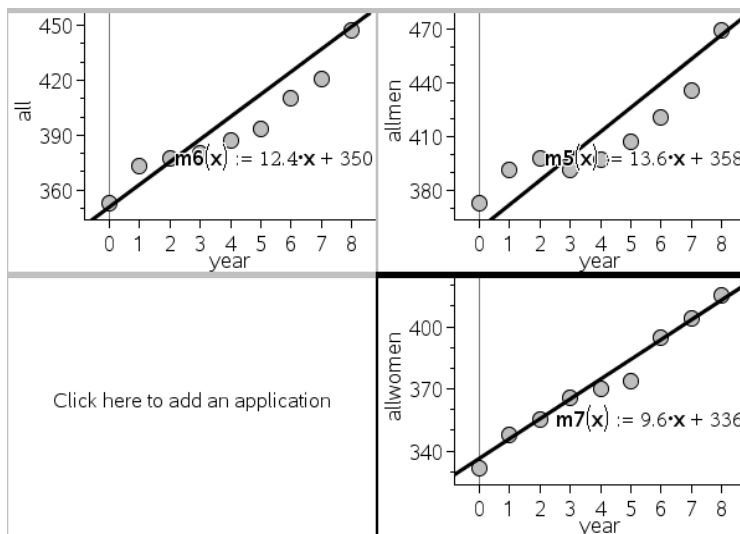


3.9

**3.10** 7. Does the data seem to have a positive or a negative correlation or no correlation?

**3.11** Go back to the scatter plots and for each Select movable line and use the hand to rotate and translate the line until you think you have the line of best fit. When you have done all 3 lines go on to the next page

**3.9 finished**



**3.12**

8. Do your lines look like a good fit?

9. What is the equation of each of your lines? (round the slope and y intercept if you want to)

**3.13** 10. Predict the median wage for 2010 and 2015 for each group using your line of best fit

Feel free to add a calculator page

**3.14** 11. Does the data in each set seem to be linear? If not, are the predictions you make likely to be fairly accurate?

**3.15**


12. What does the slope of the line of best fit mean in the context of this problem?

13. Which set of data has the highest slope?

14. What does that say about the wages of that group?


**3.16** The next set is weekly wages for white workers ages 16-24. The data is divided by gender.

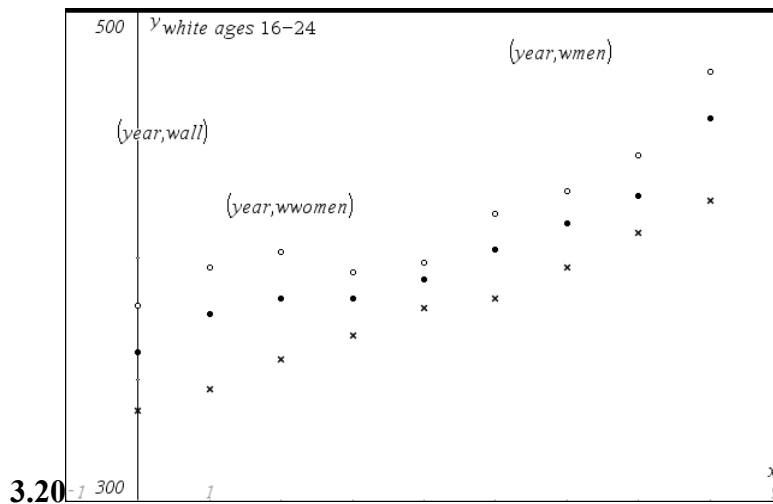
	A	year	B	wall	C	wmen	D	wwom...	E	F	G
◆											
1		0		361		380		337			
2		1		377		396		346			
3		2		383		402		358			
4		3		383		394		368			
5		4		391		398		379			
6		5		403		418		383			
7		6		414		427		396			
8		7		425		442		410			
9		8		457		476		423			
10											
11											
12											
3.17	A1	0									

<b>Question</b>
15. State 5 observations about the data in the table. Note differences between this set of data and the first set.
<b>Answer</b> 
A. B. C. D. E.

3.18



<b>Question</b>	
16. What questions do your observations bring to mind? On the next page you will see a scatterplot of the data from the spreadsheet.	
<b>Answer</b>	



**3.21**

17. What do the tick marks on the scatter plot on page 3.20 stand for? You might need to look at the window settings to answer this.

18. What is the range of wages in the first set of data for men, women and all workers?

### 3.22 Next we will look at lines of best fit for all White workers

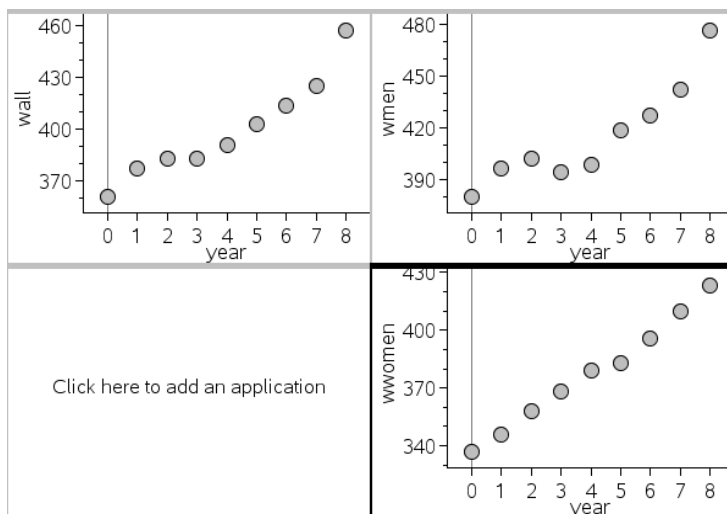
Insert 3 data and statistics pages and a blank. “ctrl”“home” “page layout” “custom split”

select the one split into 4 pieces

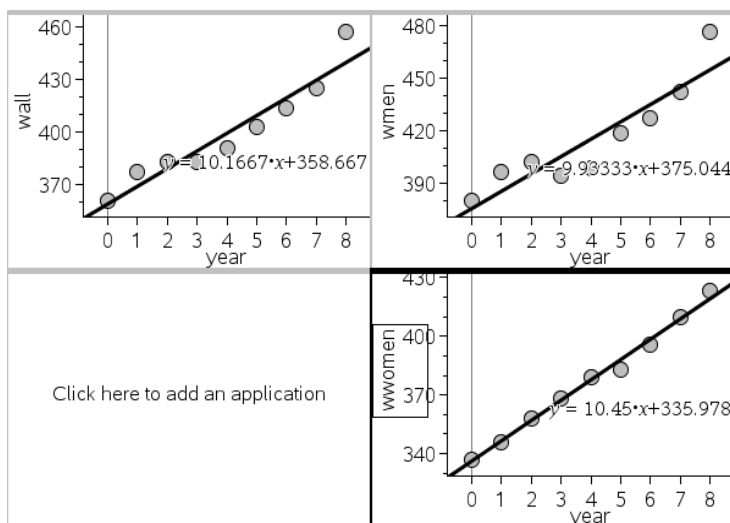
This time we will let the handheld calculate the lines of best fit. Once you have your

scatter plots drawn, go to menu, analyze, regression, show linear (mx+b)

New page to be inserted by student



Finished page inserted by student



**3.23** 19. What are the equations of the lines of best fit?

20. Predict the median wages for 2010 and 2015 for each group using your line of best fit

Feel free to add a calculator page

**3.24** 21. Does the data in each set seem to be linear? If not, are the predictions you make likely to be fairly accurate?

22. Which set of data for whites is most linear? For which set of data is a line not a good fit?

**3.25** 23. What does the slope of the line of best fit mean in the context of this problem?

24. Which set of data has the highest slope?

25. What does that say about the wages of that group?

**3.26** This next set is weekly wages Black workers ages 16-24. The data is divided by gender.

	Ayear	Bball	Cbmen	Dbwomen	E	F	G
1	0	317	319	315			
2	1	334	329	337			
3	2	350	364	343			
4	3	363	368	354			
5	4	346	381	328			
6	5	327	331	323			
7	6	386	394	375			
8	7	389	401	368			
9	8	405	425	367			
10							
11							
12							

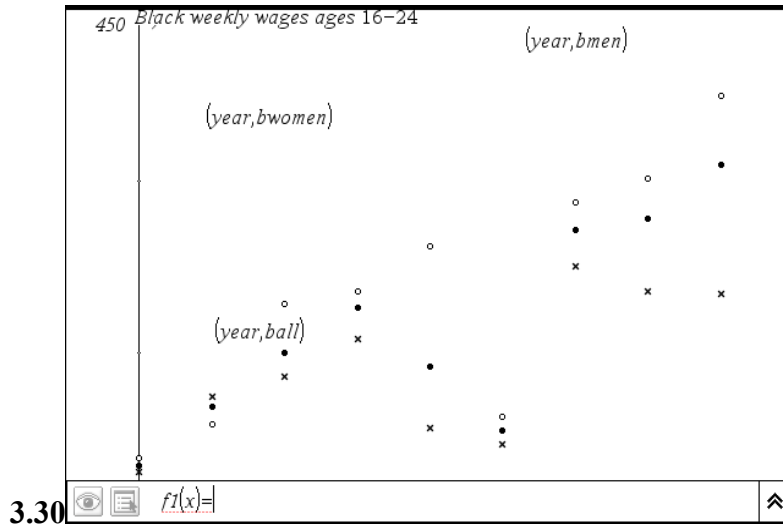
**3.27** A1 0

**3.28**

26. State 5 observations about the data in the table. Again, compare the other sets of data to this one.

### 3.29

27. What questions do your observations bring to mind?



### 3.30

3.31 28. Does this data look different than the last sets?

29. Is there a year that seems to be wrong?

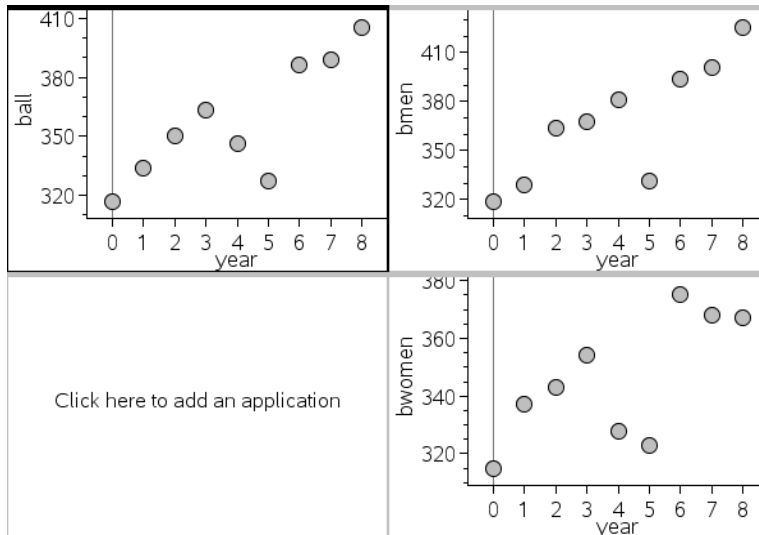
3.32 Next we will look at lines of best fit for Black workers

Insert 3 data and statistics pages for ball, bmen and bwomen. Select the page layout as you did in the last part

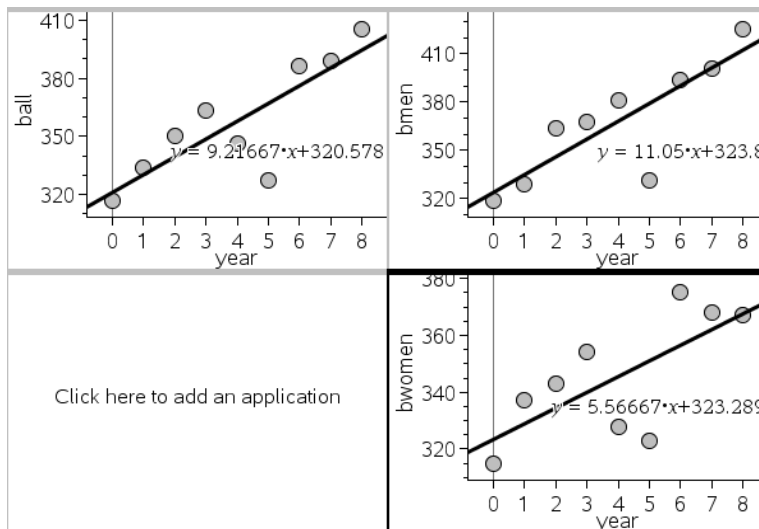
Before you draw your lines of best fit, look at the graphs and decide whether the data has a strong positive or negative correlation, moderate positive or negative correlation or no correlation.

This time we will let the handheld calculate the line of best fit. Once you have your scatter plot drawn, go to menu, analyze, regression, show linear(mx+b)

Page inserted by students



Final view of inserted page



**3.33** 30. Which set of data seems to have no correlation?

31. Does the data make sense?

32. Do you think that the Bureau of statistics made a mistake?

**3.34** 33. What are the lines of best fit calculated by the handheld

34. Predict the median wage for 2010 and 2015 using your line of best fit for each group

Feel free to add a calculator page

**3.35** 35 Does the data in each set seem to be linear? If not, are the predictions you made likely to be fairly accurate?

36. Which set of data for blacks looks most linear? For which set of data is a line not a good fit?

**3.36** 37. What does the slope of the line of best fit mean in the context of this problem?

38. Which set of data has the highest slope?

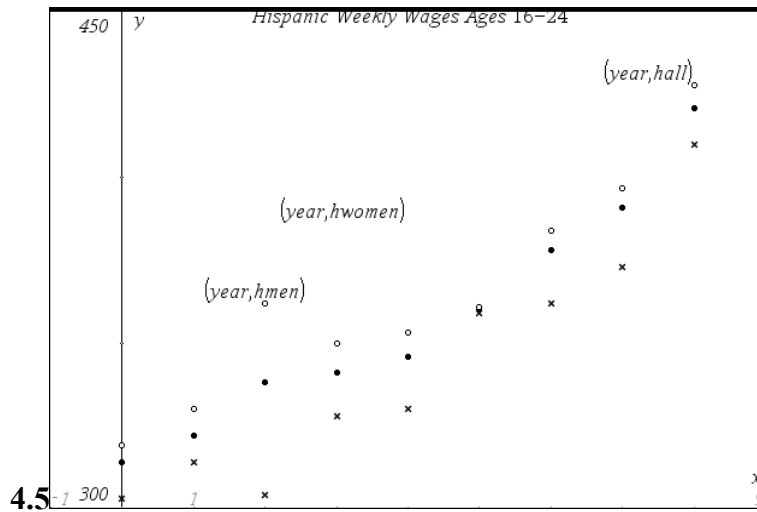
**4.1** This data set is weekly wages for Hispanic workers ages 16-24. The data is divided by gender.

	A year	B hall	C hmen	D hwomen	E	F	G
1	0	314	319	303			
2	1	322	330	314			
3	2	338	362	304			
4	3	341	350	328			
5	4	346	353	330			
6	5	360	361	359			
7	6	378	384	362			
8	7	391	397	373			
9	8	421	428	410			
10							
11							
12							

**4.2** A1 0

**4.3** 39. State 5 observations about the data in the table Again, compare the other sets of data to this one.

**4.4** 40. What questions do your observations bring to mind?



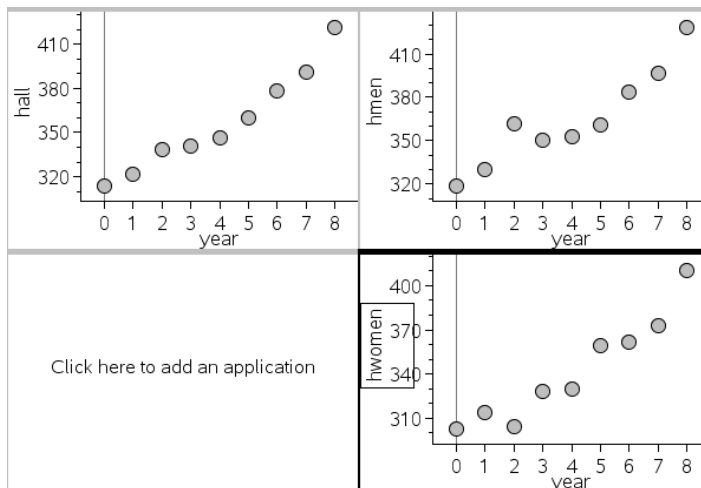
4.6 41. What do the tick marks on the scatter plot on page 3.41 stand for? You might need to look at the window settings to answer this.

42. What is the range of wages in the first set of data for men, women and all workers?

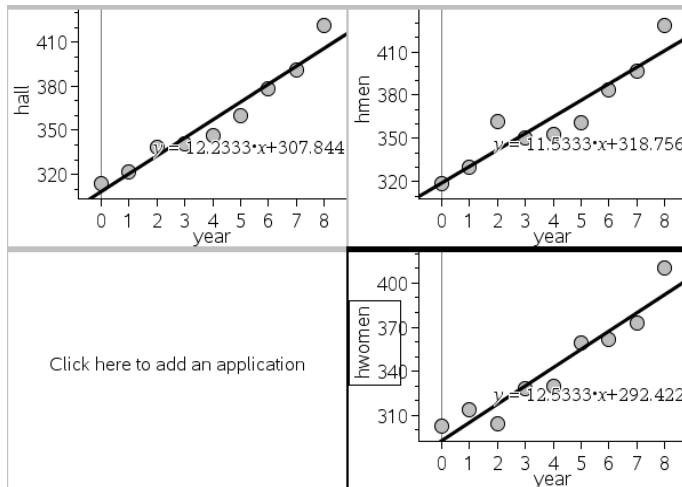
4.7 Add data and spreadsheet pages and find the lines of best fit

Use the split layout that you used before

Page added by student



Final view of page added by student



**4.8** 42. What are the equations of the lines of best fit? Are they good predictors?

43. Predict the wages for all three groups for 2010 and 2015

44. Which group has the largest annual increase in wages?

**4.9** This problem set is weekly wages for Asian workers ages 16-24. The data is divided by gender.

	A year	B aall	C amen	D awomen	E	F	G
1	0	347	355	341			
2	1	436	423	449			
3	2	394	392	396			
4	3	404	391	435			
5	4	404	405	402			
6	5	437	459	384			
7	6	487	483	496			
8	7	535	677	502			
9	8	465	508	420			
10							
11							
12							

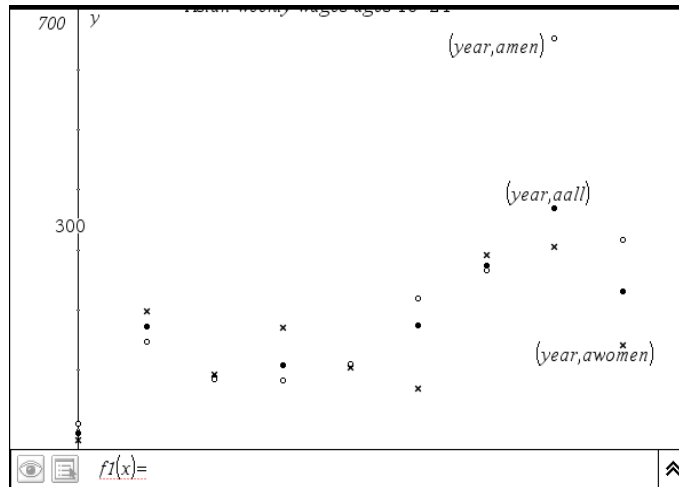
**4.10** A1 0

**4.11** 45. State 5 observations about the data in the table Again, compare the other sets of



data to this one.

**4.12** 46. What questions do your observations bring to mind?



**4.13**

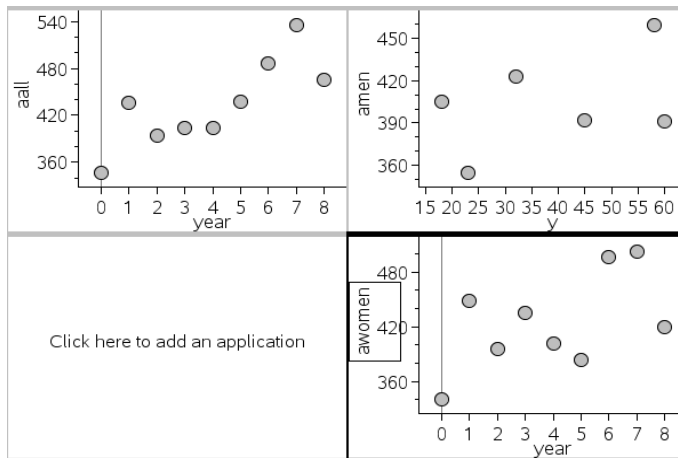
**4.14**

47. What do the tick marks on the scatter plot on page 4.6 stand for? You might need to look at the window settings to answer this.

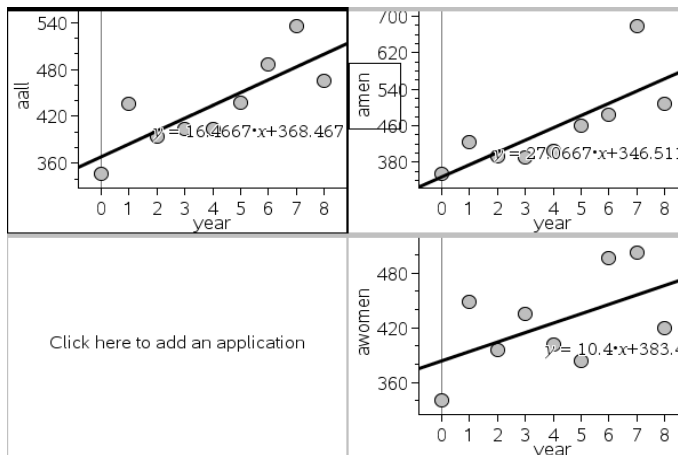
48. What is the range of wages in the first set of data for men, women and all workers?

**4.15** Add data and spreadsheet pages and find the lines of best fit. Use the split layout that you used before

Page added by student



Final view of page added by student



**4.16** 49. What are the equations of the lines of best fit? Are they good predictors?

50. Predict the wages for all three groups for 2010 and 2015

51. Which group has the largest annual increase in wages?

**4.17** You will now split up into groups and compare and contrast different groups, such as men from each ethnicity, women from each or everybody from each. The data for all groups will be at the start of problem 5

Project 1

**5.1** The next five pages have all of the data sets from problem 3. All you have to do is

start a new spreadsheet and, in the column headings, write the same title you see on the set of data you want. The data will automatically appear for you. You can then use it to compare and contrast your data.

**5.2**

	A year	B all	C allmen	D allwo...	E	F	G
•							
1	0	353	373	332			
2	1	373	391	348			
3	2	377	398	355			
4	3	380	391	366			
5	4	387	397	370			
6	5	393	407	374			
7	6	410	421	395			
8	7	421	436	404			
9	8	447	469	415			
10							
11							
12							
	A1	0					

**5.3**

	A year	B wall	C wmen	D wwom...	E	F	G
•							
1	0	361	380	337			
2	1	377	396	346			
3	2	383	402	358			
4	3	383	394	368			
5	4	391	398	379			
6	5	403	418	383			
7	6	414	427	396			
8	7	425	442	410			
9	8	457	476	423			
10							
11							
12							
	A1	0					



## Final Project

**5.7** Your final project will be to work with your group to find data about your shop area and present a project that will analyze the data. The teacher has some data for you to look at, but you will have to find more on the internet.

### Answers to Population Questions

Page 1.5 #1 299.4 million

2. 198.8 million

3. 19.2%

4. 22.3%

5. 86.2 %

6. a list of 100 words, White, Black Hispanic, Asian and Other The number of times each is written is the same as the percent

7. 1% of the population

8. No they would only total 34% of the population

9. The count is the percent of the population

10. The bars change to dots and the dots form the pie chart.

11. Yes, there was one dot for each percent

12. Yes. All of the population was counted so the percents added up to 100. If they did not, it could be due to a rounding error.

13. White 5.4 million

14. yes

15. yes There are more Blacks than Hispanics

16. White is a little smaller, Blacks a little larger, Asian almost double, Hispanic a bit smaller and Other stayed the same

17. fewer Whites, Blacks same as NJ. Asian double, Hispanics doubled and Other in half

18. Whites got a lot smaller, Black stayed the same, Asian doubled, Hispanics doubled, Other got smaller

19. The percentages changed so the pieces of the pie had to change accordingly

20. Hispanics

21. No, in the Other charts, Whites were first. In the US and Passaic County, Hispanics were second and in NJ Hispanics were third

22. Hispanics are first, Black second and Whites third

23. It is very different from the rest. The Hispanic population is almost half of the population where in the US and NJ Whites were more than half In Passaic county the number of Whites is almost the same size as the number of Whites in Paterson. Blacks and Whites are almost equal in Paterson, although Blacks exceed the Whites. The Asian population is smaller in Paterson than anywhere else and Other is the same in Passaic County but smaller than in the US and NJ

### Answers to Wage Questions

1. Median wage means if you put all the wages in order from smallest to largest, the one in the middle is the one used
2. The median eliminates the outliers and is more representative of the person in the middle
3. Sample answers.
  - A. Men make more than women.
  - B. Men make more than everyone
  - C. Wages in each category went up each year except men in 2003
  - D. Women are losing ground ( in 2000, men made \$41 more and in 2008 made \$54 more
  - E. Men took 2 years to get back to their 2002 income
  - F. The changes are different each year
4. Answers will vary
5. The tick marks are every \$50 so \$350, \$400, and \$450
6. All workers 94, men 96 and women 83
7. The data seems to have a positive correlation?
8. Pretty good
9. Answers will vary slightly
 
$$\text{all} = 12.4x + 350$$

$$\text{men} = 13.6x + 358$$



$$\text{women} = 9.6x + 336$$

10. Answers will vary depending on answers to #9

	2010	2015
All	474	536
Men	494	562
Women	431	432

11. The data appears quite linear so the predictions are pretty good.

12. The increase in wages every year

13. Men

14. Men are getting better increases every year than women

15. Answers will vary possible observations

Wages for Whites are higher than for everyone

Wages dropped in 2002 and 2003 for men

Wages for all whites remained constant in 2002 and 2003

Women had no drop in wages

Men are still increasing wages faster than women

16. Answers will vary

17. 50% increments \$350, \$400, \$450

18. Range all 96

Men 96

Women 86

19. All =  $10.2x + 359$  men =  $9.9x + 375$  women =  $10.4x + 336$

20.

	2010	2015
All	461	512
Men	474	523. 50
Women	440	492

21. Women seem almost linear . Men and everyone are not linear. The predictions for women will be more accurate than for the others
22. Women are most linear. The data for men and everyone are not good fits, but men is worst.
23. The slope is the increase in wages every year
24. Women
25. Their wages are growing the fastest. However. Since the line for men is not very good, this is deceiving.
26. Answers will vary some possible observations are:
- A. wages for everyone dropped in 2004 and 2005
  - B. Wages for men dropped in 2005
  - C. Wages for women dropped in 2004 and 2005 and again in 2007 and 2008
  - D. Men make more than women
  - E. Men and women were almost equal in 2000
  - F. Men were way ahead of women in 2008
27. answers will vary

28. Yes, it has a marked dip in the middle (2004 and 2005)

29. Yes, 2004 and 2005

30. Black women

31. No

32. The data seems very odd so maybe someone made a typographical error

33. All =  $9.2x + 321$  men =  $11.05x + 324$  women =  $5.56x + 323$

34.

	2010	2015
All	413	459
Men	434.50	489.75
Women	378.60	406.40

35. No. For everyone and men linear is fairly good, but there seems to be no correlation for women. The predictions for women will probably not be good

36. Students can argue everyone or men. Women is definitely not a good fit.

37. Slope means increase in yearly wages

38. Men

39. Sample possible responses

A. Wages for everyone and men went up each year but women dropped in 2002

B. Women are catching up to the men

C. All three groups had the same range over the 9 year period

D. Wages for men were the same as for Blacks in 2000

E. Hispanic women made less than Black Women in 2000

F. Hispanic women made more money than Black women in 2008

40. \$50 each      \$350    \$400

41. All    107    Men    107    Women                    107

42. All =  $12.2x + 308$       men =  $11.5x + 319$     women =  $12.5x + 292$

43.

	2010	2015
All	430	491
Men	434	491.5
Women	417	479.5

44.

45. Women

46. Answers will vary. Possible answers

A. Drop in wages for everyone from 2001 through 2005

B. Drop for men in 2001 through 2006 and again in 2008

C. Women are up and down throughout the period

D. Men increased faster than women over the 9 years

E. Asians made more money than Hispanics

47. Answers will vary

48. 50 each                    \$350 \$400    \$450    \$500    \$550    \$600    \$650

49. All    118    men    153    women                    79

50. Everyone =  $16.5x + 368$       men =  $27.1x + 347$       women =  $10.4x + 383$

not too bad for men but not good for everyone and women

51.

	2010	2015
All	533	615.50
Men	618	753.5
Women	487	539

52. Men

### Rubric for Problem 4

(Timetable 3 days) plus presentation

1. Creative Ability (20 points)
  - A. Does the project show creativity and originality? (Did the group find some things with your data that we did not do in problem 2?)
  - B. Presentation of the Project
2. Mathematical Thought (30 points)
  - A. Is your set of data clearly defined?
  - B. Are your comparisons and contrasts carefully thought out?
    1. What things did you have to consider in order to compare the different sets of data?
    2. Did you investigate why differences occurred?
    3. Can you support your conclusions?
    4. Does the project demonstrate an understanding of data analysis?
    5. Did you use more than one type of representation to do your comparisons?
3. Thoroughness (20 points)
  - A. How completely did you cover the topic?
  - B. How complete are your notes?
  - C. Did the project show independent thinking and not just repeat problem 3?
4. Skill (30 points)
  - A. How clearly does the group discuss the project, including proper terminology

and conclusions?

B. Does the group demonstrate knowledge of analyzing and presenting data?

### Rubric for Problem 5

(Timetable approximately 2 weeks)

By the end of the first week you should have all of your initial data entered into your handheld. As you start analyzing the data, you might find a need for additional data. By Wednesday of the second week you should have your charts and plots all done and you should be analyzing your data. By the end of the second week you should be ready to present your project to the class.

#### 5. Creative Ability (20 points)

C. Does the project show creativity and originality? (Did the group find some things with your data that we did not do in problem 2 or 3? Maybe find a way to incorporate the types of graphs in problem 1)

#### D. Presentation of the Project

#### 6. Mathematical Thought (30 points)

C. Is your set of data clearly defined?

D. Are your comparisons and contrasts carefully thought out?

6. What things did you have to consider in order to compare the different sets of data?

7. Did you investigate why differences occurred?

8. Can you support your conclusions?

9. Does the project demonstrate an understanding of data analysis?

10. Did you use more than one type of representation to do your comparisons?



7. Thoroughness (20 points)

D. How completely did you cover the topic?

E. How complete are your notes?

F. Did the project show independent thinking and not just repeat problem 3?

8. Skill (30 points)

A. How clearly does the group discuss the project, including proper terminology and conclusions.

## Transcript of the Data Analysis Unit of Instruction for the TI-84

### Introduction:

- A. We will start our exploration by looking at population data for the USA, NJ, Passaic County and Paterson. Because some people consider themselves more than one ethnicity, numbers have been slightly adjusted when necessary. Data is for the year 1996 and is divided by ethnicity and gender. The first set of data is for the USA
- B. Data for the US and NJ are reported in 1,000,000's  
Data for Passaic County and Paterson are reported in 1,000's

### Problem 1 Part I

- A. The data is rounded to the nearest 100,000 and is reported in 100,000,000's.  
You cannot enter words in this list so you will need to code your ethnicities.  
White will be 1, Black 2, Asian 3, Hispanic 4, and other 5.
- B. Go to **Stat Edit** and then put your cursor at the top of **L1** so the “word” **L1** is highlighted press **2<sup>nd</sup> Del** and type **eth**. Use the right arrow to get to the top of column **L2** press **2<sup>nd</sup> Del** and type **uspop**. In column **eth** enter the numbers 1, 2, 3, 4, 5 In column **uspop** enter the numbers you see in the spreadsheet below.

	A ethnicity	B uspop	C	D
1	white	198.8		
2	black	38.2		
3	asian	13.2		
4	hispanic	44.3		
5	other	4.9		
6				
	A1 ="white "			

1. What was the approximate population of the United States in 1996? Round your answer to the nearest 100,000.

---

2. How many White people were there?

---

3. The number of Blacks is what fraction of the number of Whites?

---

4. The number of Hispanics is what fraction of the number of Whites?

---

5. The number of Blacks is what fraction of the number of Hispanics?

---

C. To create a bar graph of the US population, press **2<sup>nd</sup> y=** highlight **ON** and press **enter**. Then use the **down arrow** to select the **histogram** (last one in the top row) and press **enter**. **Down arrow** to **XList** and enter **ETH** and for **Freq** enter **USPOP**.

D. Next set you **Window** at

Xmin	1
Xmax	6
Xscl	1
Ymin	0
Ymax	200
Yscl	1

Once your window is set, press **Graph** and you will see your bar graph.

6 . What does each bar represent? \_\_\_\_\_

7. If you combined the Asian, Black, Hispanic, and Other categories, how would it compare to the White population?

---



---

E. If the population of the United States was about 299.4 million, find the percent of people in each ethnic group. Round the percents off to the nearest integer. Fill in the chart below

ethnicity	uspop	uspercent	degrees
1	198.8		
2	38.2		
3	13.2		
4	44.3		
5	4.9		

You will use the percents that you entered to find number of degrees that should be in a pie chart. Enter the number of degrees for each sector(piece) in the chart above.

8. Draw the pie chart Make sure that the chart has a title and the correct number of degrees in each sector. Use a protractor to draw your sectors accurately.

9. a. What is similar in the bar graph and the pie chart? \_\_\_\_\_

\_\_\_\_\_

b. Can you get the same information from each graph?

\_\_\_\_\_

10. Do the pieces in the pie seem to agree with the percents in the spreadsheet? Why or why not?

\_\_\_\_\_

11. Do the percents add up to 100? Why or why not?

\_\_\_\_\_

## Problem 1 Part 2

- A. The next set of data is NJ. The population in 1996 was about 8.7 million. The data is reported to the nearest 1,000,000 and is rounded to the nearest 100,000.
- B. Go to Stat Edit on your calculator and insert a new column (at the top of the next column press **2<sup>nd</sup> Del** and type **njpop**. Enter the data from the chart below.

	A ethnic...	B njpop	C	D
1	white	5.4		
2	black	1.3		
3	asian	0.6		
4	hispanic	1.2		
5	other	0.2		
6				
AI	="white "			

C. To create a bar graph of the NJ population, press **2<sup>nd</sup> y=** highlight **ON** and press **enter**. Then use the **down arrow** to select the **histogram** (last one in the top row) and press **enter**. **Down arrow** to **XList** and enter **ETH** and for **Freq** enter **NJPOP**. Adjust the window to see the bar chart clearly.

12. Which ethnicity has the highest population in New Jersey? How many people are in that group?

---

13. Is this the same group as the US population?

---

14. Have the rankings of any groups changed?

---

If the population of New Jersey in 1996 was about 8.7 million, find the percent of people

in each ethnic group. Round your answers to the nearest percent. Fill in the percent column below.

ethnicity	njpop	njpercent	degrees
White	5.4		
Black	1.3		
Asian	0.6		
Hispanic	1.2		
Other	0.2		

You will use the percents that you entered to find number of degrees that should be in a pie chart. Enter the number of degrees for each sector(piece) in the chart above.

15. Draw the pie chart for NJ.

Compare the pie chart for the US and the one for NJ.

16. What sectors of the pie chart are about the same size in both charts and which ones have changed?

- A. The next set of data is Passaic County. The population of Passaic County in 1996 was about 489.1 thousand.

The data this time is given in percents, rounded to the nearest integer.

Ethnicity	Percent
White ( 1)	48
Black ( 2)	15
Asian (3)	5
Hispanic (4)	31
Other	1

Enter the data in your calculator in a column called pper.

- B. If the population of Passaic County in 1996 was about 497.1 thousand, find the number of people in each ethnic group. Call column C “pcpop”. Enter the data (in thousands), rounded to the nearest 100 in the chart below.



C.

ethnicity	pcper	pcpop	degrees
White (1)	48		
Black (2)	15		
Asian (3)	5		
Hispanic (4)	31		
Other (5)	1		

D. Go to Stat Edit on your calculator and insert a new column (at the top of the next column press **2<sup>nd</sup> Del** and type **pcpop**. Enter the data from the chart above.

E. C. To create a bar graph of the Passaic County population, press **2<sup>nd</sup> y=** highlight **ON** and press **enter**. Then use the **down arrow** to select the **histogram** (last one in the top row) and press **enter**. **Down arrow** to **XList** and enter **ETH** and for **Freq** enter **PCPOP**. Adjust the window to see the bar chart clearly

17. How do the percents of each ethnicity in Passaic County compare with the US and NJ?

---

You will use the percents that you entered to find number of degrees that should be in a pie chart. Enter the number of degrees for each sector(piece) in the chart above.

18. Draw the pie chart for Passaic County.

Compare the pie chart for the US and the one for NJ.

19. What did you notice about the pieces of the pie? (Are the pieces for each ethnicity the same size as the pieces in the former pie charts)?

---

20. If not, which pieces are bigger and which are smaller?

Why? \_\_\_\_\_

#### Problem 1 Part 4

A. The next set of data is for Paterson, NJ. The population of Paterson in 1996 was about 148.7 thousand.

B. The data is in percents, rounded to the nearest integer.

Ethnicity	percent
White (1)	26
Black (2)	28
Asian (3)	2
Hispanic (4)	43

Other (5)	1
-----------	---

21. Which ethnicity has the largest population?

\_\_\_\_\_

22. Is this the same as for the USA, NJ and Passaic

County? \_\_\_\_\_

- C. If the population of Passaic County in 1996 was about 497.1 thousand, find the number of people in each ethnic group. On the next page enter the data (in thousands), rounded to the nearest 100 in the chart on the below.

Ethnicity	patpercent	Papop	Degrees
White (1)	26		
Black (2)	28		
Asian (3)	2		
Hispanic (4)	43		
Other (5)	1		

D.

Create a column **Patpop** and enter your Paterson populations. (Go to Stat Edit on your calculator and insert a new column (at the top of the next column press **2<sup>nd</sup> Del** and type **papop**.) Enter the data from the chart above.

- E. To create a bar graph of the Passaic County population, press **2<sup>nd</sup> y=** highlight **ON** and press **enter**. Then use the **down arrow** to select the **histogram** (last one in the top row) and press **enter**. **Down arrow** to **XList** and enter **ETH** and for **Freq** enter **PCPOP**. Adjust the window to see the bar chart clearly.

- F. You will use the percents that you entered to find number of degrees that should be in a pie chart. Enter the number of degrees for each sector(piece) in the chart above.

23. Draw the pie chart for Paterson.

24. What is different about Paterson's population?

---

---

25. What observations can you make comparing the spreadsheets, bar charts and pie charts for the US, NJ, Passaic County and Paterson.

---

---

---

### Problem 2

The next problem is a study of comparisons of 16-24 year old full time workers' median wages separated by ethnicity. We will look at everyone, Whites, Blacks, Hispanics and Asians

Statistics are from the Bureau of Labor and Statistics

1. What does median income mean?

---



---

2. Why does the Bureau of Labor and Statistics use the median and not the mean or mode?

- 
- A. As you start this problem you will see data for workers of all ethnicities combined.

The data is divided by gender.

In all of the spreadsheets and scatter plots let the year 2000 be indicated as year 0, 2001 is 1, etc.

- B. Look at the data and answer the questions

Year	All	Allme	Allwo
0	353	373	332
1	373	391	348
2	377	398	355
3	380	391	366

<b>4</b>	<b>387</b>	<b>397</b>	<b>370</b>
<b>5</b>	<b>393</b>	<b>407</b>	<b>374</b>
<b>6</b>	<b>410</b>	<b>421</b>	<b>395</b>
<b>7</b>	<b>421</b>	<b>436</b>	<b>404</b>
<b>8</b>	<b>447</b>	<b>469</b>	<b>415</b>

3.State 5 observations about the data

---

---

---

---

---

---

---

4. What questions do your observations bring to mind?

---

---

---

---

---

- **C.** Enter the data from the table into lists. To do this press **STAT EDIT** Go all the way to the **top of a column** and press **2<sup>nd</sup> Del** to insert a new column **name the columns the same way they are named in the table above**. Once you have written the name press

ENTER and the **down arrow**. **Enter the data**. We will now create a scatter plot from your data. Press **2<sup>nd</sup> y= (Statplot)** then **1 Highlight ON** and press **enter**. Use the **down arrow** to get to **TYPE** select the **first choice**, enter, **down arrow** to **XLIST** and type **YEAR**, in **YLIST** type **all**, choose the **first MARK** and press **enter**. Press **ZOOM** and **ZSTAT**. You should see a scatter plot of the first set of data.

- **D. Go to Statplot** again and turn on the second plot. Repeat the steps you just did, but this time make **YLIST ALLME** and choose the **second MARK**. Press **ZSTAT** to see the second plot. Repeat to turn **on the third plot**, making **YLIST ALLWO** and **choose the third mark**. Again do **ZSTAT**.

5. What do the tick marks on the scatter plot count by? You might want to change the window settings on the y axis to 50 so you can see the tick marks and not a “Fat” y-axis.

---

6. What is the range of wages in the first set of data for men, women and all workers?

---

- **E. Next we will look at lines of best fit for all workers**

7. Does the data seem to have a positive or a negative correlation or no correlation?

---

- **F. Go to STATPLOT** and turn OFF plots 2 and 3. **Go to STAT CALC** Press the up arrow to get to the bottom of the list and choose ) **0. Manual-Fit** You will see a + on your screen, move it until it is at one end of what you think is the line of best fit. Once you like where the + is, press **enter**. (Note: You cannot move this point once you press enter). **Use the arrows to draw the line of best fit. When you like your line press**

**enter and the equation of the line will appear.**

- a. What is the equation of your line of best fit?

---

**G. Turn off PLOT 1 and turn off Y1** (Put the cursor on the = and press enter) and **turn on PLOT 2 and graph it.** Find the line of best fit the same way did for the first plot

- b. What is your equation for the line of best fit? (a is m in  $y=mx+b$ ). Round a and b off to the nearest whole number. \_\_\_\_\_ Go to **Y=** and in **y2 enter your equation.** And graph it.

**H. Repeat for plot 3**

- c. What is your line of best fit?

---

8. Are your lines a good fit?

---

9. Write the equations of each of your lines?

---



---

10. Predict the median wage for 2010 and 2015 for each group using your line of best fit

---

11. Does the data in each set seem to be linear? \_\_\_\_\_ If not, are the predictions you make likely to be fairly accurate?

---

12. What does the slope of the line of best fit mean in the context of this problem?



---

13. Which set of data has the highest slope?

---

14. What does that say about the wages of that group?

---



---

- **I.** The next set is weekly wages for white workers ages 16-24. The data is divided by gender.

Year	Wall	wmen	wwome
0	361	380	337
1	377	396	346
2	383	402	358
3	383	394	368
4	391	398	379
5	403	418	383
6	414	427	396
7	425	442	410
8	457	476	423

15. State 5 observations about the data

---

---

---

---

---

---

---

---

16 . What questions do your observations bring to mind?

---

---

---

---

---

---

---

- **J.** Enter the data from the table into lists. To do this press **STAT EDIT** Go all the way to the **top of a column** and press **2<sup>nd</sup> Del** to insert a new column **name the columns the same way they are named in the table above**. You do not have to repeat the year column. Once you have written the name press **ENTER** and the **down arrow**. **Enter the data**. We will now create a scatter plot from your data. **Press 2<sup>nd</sup> y= (Statplot) then 1 Highlight ON and press enter** Use the **down arrow to get to TYPE** select the **first choice**, enter, **down arrow to XLIST and type YEAR**, in **YLIST type WALL**, choose the **first MARK** and press **enter**. Press **ZOOM** and **ZSTAT**. You should see a scatter

plot of the first set of data.

- **K.** Go to **Statplot** again and turn on the second plot. Repeat the steps you just did, but this time make **YLIST WMEN** and choose the **second MARK**. Press **ZSTAT** to see the second plot. Repeat to turn **on the third plot**, making **YLIST WWOME** and **choose the third mark**. Again do **ZSTAT**.

17. What do the tick marks on the scatter plot count by? You might want to change the window settings on the y axis to 50 so you can see the tick marks and not a “Fat” y-axis.

---

18. What is the range of wages in the first set of data for men, women and all workers?

- 
- **L.** Next we will look at lines of best fit for White workers

19. Does the data seem to have a positive or a negative correlation or no correlation?

---

**Insert three plots like you did before using Year for the XLIST and WALL, WMEN, and WWOME for the three YLISTs.**

This time we will let the handheld calculate the lines of best fit. **Go to Y= and delete all equations**

**Go to STATPLOT and turn OFF plots 2 and 3**

- **M.** Press **STAT CALC LinReg(ax+b)** **2<sup>nd</sup> stat** **◄** **▲** You will see an **L** type **YEAR** , **2<sup>nd</sup> stat** **◄** **▲** You will see an **L** type **WALL** and press **enter** (*Don't forget the comma*)

19a. What is your equation for the line of best fit. (a is m in  $y=mx+b$ ). Round a and b off to the nearest whole number. \_\_\_\_\_ Go to **Y=** and in **Y1** **enter your equation**. And graph it.

- **N.** Repeat for plot 2. **Turn off PLOT 1** and **turn off Y1** (Put the cursor on the + and press enter) and **turn on plot 2** and **graph it**. This time we will let the calculator find the line of best fit. **Press STAT CALC LinReg(ax+b) 2<sup>nd</sup> stat ⌵ ▲** You will see an L type **YEAR**, **2<sup>nd</sup> stat ⌵ ▲** You will see an L type **WMEN** and press **enter**

19b. What is your line of best fit?

\_\_\_\_\_

- **O.** Repeat for plots3. **Turn off PLOT 12** and **turn off Y2** (Put the cursor on the + and press enter) and **turn on plot 3** and **graph it**. This time we will let the calculator find the line of best fit. **Press STAT CALC LinReg(ax+b) 2<sup>nd</sup> stat ⌵ ▲** You will see an L type **YEAR**, **2<sup>nd</sup> stat ⌵ ▲** You will see an L type **WWOME** and press **enter**

19c. What is your line of best fit?

\_\_\_\_\_

20. Predict the median wages for 2010 and 2015 for each group using your lines of best fit

\_\_\_\_\_

\_\_\_\_\_

21. Does the data in each set seem to be linear? If not, are the predictions you make likely to be fairly accurate?

\_\_\_\_\_

22. Which set of data for whites is most linear? For which set of data is a line not a good fit?

---

23. What does the slope of the line of best fit mean in the context of this problem?

---



---

24. Which set of data has the highest slope?

---

25. What does that say about the wages of that group?

---

- **P.** This next set is weekly wages black workers ages 16-24. The data is divided by gender.

YEAR	BALL	BMEN	BWOME
0	317	319	315
1	334	329	337
2	350	364	343
3	363	368	354
4	346	381	328
5	327	331	323
6	386	394	375
7	389	401	368

8	405	425	367
---	-----	-----	-----

26. State 5 observations about the data

---

---

---

---

---

---

---

---

---

27 . What questions do your observations bring to mind?

---

---

---

---

---

---

---

---

---

- **Q.** Enter the data from the table into lists. To do this press **STAT EDIT** Go all the way to the **top of a column** and press **2<sup>nd</sup> Del** to insert a new column **name the columns the same way they are named in the table above**. You do not have to repeat the year

column. Once you have written the name press ENTER and the **down arrow**. **Enter the data**. We will now create a scatter plot from your data. **Press 2<sup>nd</sup> y= (Statplot) then 1 Highlight ON and press enter** Use the **down arrow to get to TYPE** select the **first choice**, enter, **down arrow to XLIST and type YEAR**, in YLIST type **BALL**, choose the **first MARK** and press **enter**. Press **ZOOM** and **ZSTAT**. You should see a scatter plot of the first set of data.

- **R. Go to Statplot again and turn on the second plot. Repeat the steps you just did, but this time make YLIST BMEN and choose the second MARK. Press ZSTAT to see the second plot. Repeat to turn on the third plot, making YLIST BWOME and choose the third mark. Again do ZSTAT.**

- 28. Does this data look different than the last sets?

---



---

- 29. Is there a year that seems to be wrong?

---



---

- **S. Next we will look at lines of best fit for Black workers**

30. Does the data seem to have a positive or a negative correlation or no correlation? \_\_\_\_\_

- **Insert three plots like you did before using Year for the XLIST and BALL, BMEN, and BWOME for the three YLISTs.**

30a. Which set of data seems to have no correlation?

---

31. Does the data make sense?

---

32. Do you think that the Bureau of statistics made a mistake?

---

- **T.** This time we will let the handheld calculate the lines of best fit.

**Go to Y= and delete all equations**

Before you draw your lines of best fit, look at the graphs and decide whether the data has a correlation.

**Go to STATPLOT and turn OFF plots 2 and 3**

- **U.** Press **STAT CALC LinReg(ax+b)** 2<sup>nd</sup> stat  $\left[ \frac{\square}{\square} \right]$   $\blacktriangle$  You will see an **L** type **YEAR** , 2<sup>nd</sup> stat  $\left[ \frac{\square}{\square} \right]$   $\blacktriangle$  You will see an **L** type **BALL** and press **enter** (*Don't forget the comma*)

33a. What is your equation for the line of best fit. (a is m in  $y=mx+b$ ). Round a and b off to the nearest whole number. \_\_\_\_\_ Go to **Y=** and in **Y1**

**enter your equation.** And graph it.

- **V.** Repeat for plot 2. **Turn off PLOT 1** and **turn off Y1** (Put the cursor on the + and press enter) and **turn on plot 2** and **graph it.** This time we will let the calculator find the line of best fit. Press **STAT CALC LinReg(ax+b)** 2<sup>nd</sup> stat  $\left[ \frac{\square}{\square} \right]$   $\blacktriangle$  You will see an **L** type **YEAR**, 2<sup>nd</sup> stat  $\left[ \frac{\square}{\square} \right]$   $\blacktriangle$  You will see an **L** type **BMEN** and press **enter**

31b. What is your line of best fit?

---



- **W.** Repeat for plots 3. **Turn off PLOT 1** and **turn off Y2** (Put the cursor on the + and press enter) and **turn on plot 3** and **graph it**. This time we will let the calculator find the line of best fit. **Press STAT CALC LinReg(ax+b) 2<sup>nd</sup> stat  $\leftarrow$   $\blacktriangle$**  You will see an L type **YEAR**, **2<sup>nd</sup> stat  $\leftarrow$   $\blacktriangle$**  You will see an L type **BWOME** and press **enter**

33c. What are the lines of best fit calculated by the handheld

---

34. Predict the median wage for 2010 and 2015 using your line of best fit for each group

---

35 Does the data in each set seem to be linear? If not, are the predictions you made likely to be fairly accurate?

---

36. Which set of data for blacks is most linear? For which set of data is a line not a good fit?

---

37. What does the slope of the line of best fit mean in the context of this problem?

---

38. Which set of data has the highest slope?

---

**AA.** This data set is weekly wages for Hispanic workers ages 16-24. The data is divided by gender.

YEAR	HALL	HMEN	HWOME

0	314	319	303
1	322	330	314
2	338	362	304
3	341	350	328
4	346	353	330
5	360	361	359
6	378	384	362
7	391	397	373
8	421	428	410

39. State 5 observations about the data in the table. Again, compare the other sets of data to this one.

---



---



---



---



---



---

40. What questions do your observations bring to mind?

---

- 
- **BB.** Enter the data from the table into lists. To do this press **STAT EDIT** Go all the way

to the **top of a column** and press **2<sup>nd</sup> Del** to insert a new column **name the columns the same way they are named in the table above**. You do not have to repeat the year column. Once you have written the name press **ENTER** and the **down arrow**. **Enter the data**. We will now create a scatter plot from your data. **Press 2<sup>nd</sup> y= (Statplot) then 1 Highlight ON and press enter** Use the **down arrow to get to TYPE** select the **first choice**, enter, **down arrow to XLIST and type YEAR**, in **YLIST** type **HALL**, choose the **first MARK** and press **enter**. Press **ZOOM** and **ZSTAT**. You should see a scatter plot of the first set of data.

- **CC.** Go to **Statplot** again and turn on the second plot. Repeat the steps you just did, but this time make **YLIST HMEN** and choose the **second MARK**. Press **ZSTAT** to see the second plot. Repeat to turn **on the third plot**, making **YLIST HWOME** and **choose the third mark**. Again do **ZSTAT**.
- **DD.** Insert three plots like you did before using **Year** for the **XLIST** and **HALL**, **HMEN**, and **HWOME** for the three **YLISTs**.

41. What do the tick marks on the scatter plot count by? You might want to change the window settings on the y axis to 50 so you can see the tick marks and not a “Fat” y-axis.

---

42. What is the range of wages in the first set of data for men, women and all workers?

---



---

- **EE.** This time we will let the handheld calculate the lines of best fit.

### Go to Y= and delete all equations

Before you draw your lines of best fit, look at the graphs and decide whether the data has a correlation.

### Go to STATPLOT and turn OFF plots 2 and 3

- FF.** Press **STAT CALC LinReg(ax+b)** **2<sup>nd</sup> stat** **☒ ▲** You will see an **L** type **YEAR** , **2<sup>nd</sup> stat** **☒ ▲** You will see an **L** type **HALL** and press **enter** (*Don't forget the comma*)

43a. What is your equation for the line of best fit. (a is m in  $y=mx+b$ ). Round a and b off to the nearest whole number. \_\_\_\_\_ Go to **Y=** and in **Y1** **enter your equation**. And graph it.
- GG.** Repeat for plot 2. **Turn off PLOT 1** and **turn off Y1** (Put the cursor on the + and press enter) and **turn on plot 2** and **graph it**. This time we will let the calculator find the line of best fit. Press **STAT CALC LinReg(ax+b)** **2<sup>nd</sup> stat** **☒ ▲** You will see an **L** type **YEAR**, **2<sup>nd</sup> stat** **☒ ▲** You will see an **L** type **HMEN** and press **enter**

43b. What is your line of best fit?

\_\_\_\_\_
- HH.** Repeat for plots 3. **Turn off PLOT 1** and **turn off Y2** (Put the cursor on the + and press enter) and **turn on plot 3** and **graph it**. This time we will let the calculator find the line of best fit. Press **STAT CALC LinReg(ax+b)** **2<sup>nd</sup> stat** **☒ ▲** You will see an **L** type **YEAR**, **2<sup>nd</sup> stat** **☒ ▲** You will see an **L** type **HWOME** and press **enter**

43c. What is the equation of the lines of best fit?

\_\_\_\_\_

\_\_\_\_\_

44. Predict the wages for all three groups for 2010 and 2015

---

45. Which group has the largest annual increase in wages?

---

- **II** This problem set is weekly wages for Asian workers ages 16-24. The data is divided by gender.

YEAR	AALL	AMEN	AWOMEN
0	347	355	341
1	436	423	449
2	394	392	396
3	404	391	435
4	404	405	402
5	437	459	384
6	487	483	496
7	535	677	502
8	465	508	420

46. State 5 observations about the data in the table. Again, compare the other sets of data to this one.

---



---



---

---

47. What questions do your observations bring to mind?

- **II.** Enter the data from the table into lists. To do this press **STAT EDIT** Go all the way to the **top of a column** and press **2<sup>nd</sup> Del** to insert a new column **name the columns the same way they are named in the table above**. You do not have to repeat the year column. Once you have written the name press **ENTER** and the **down arrow**. **Enter the data**. We will now create a scatter plot from your data. Press **2<sup>nd</sup> y= (Statplot)** then **1 Highlight ON and press enter** Use the **down arrow to get to TYPE** select the **first choice**, enter, **down arrow to XLIST and type YEAR**, in **YLIST** type **aALL**, choose the **first MARK** and press **enter**. Press **ZOOM** and **ZSTAT**. You should see a scatter plot of the first set of data.
- **JJ.** Go to **Statplot** again and turn on the second plot. Repeat the steps you just did, but this time make **YLIST AMEN** and choose the **second MARK**. Press **ZSTAT** to see the second plot. Repeat to turn **on the third plot**, making **YLIST AWOME** and **choose the third mark**. Again do **ZSTAT**.
- **DD.** Insert three plots like you did before using **Year** for the **XLIST** and **AALL**, **AMEN**, and **AWOME** for the three **YLISTs**.

48. What do the tick marks on the scatter plot count by? You might want to change the window settings on the y axis to 50 so you can see the tick marks and not a “Fat” y-axis.

---

---

49. What is the range of wages in the first set of data for men, women and all workers?

---



---

- **KK.** This time we will let the handheld calculate the lines of best fit.

**Go to Y= and delete all equations**

Before you draw your lines of best fit, look at the graphs and decide whether the data has a correlation.

**Go to STATPLOT and turn OFF plots 2 and 3**

- **LL.** Press **STAT CALC LinReg(ax+b)** 2<sup>nd</sup> stat  $\blacktriangle$  You will see an L type **YEAR** , 2<sup>nd</sup> stat  $\blacktriangle$  You will see an L type **AALL** and press **enter** (*Don't forget the comma*)

50a. What is your equation for the line of best fit. (a is m in  $y=mx+b$ ). Round a and b off to the nearest whole number. \_\_\_\_\_

Go to **Y=** and in **Y1** enter your equation. And graph it.

- **MM.** Repeat for plot 2. **Turn off PLOT 1** and **turn off Y1** (Put the cursor on the + and press enter) and **turn on plot 2** and **graph it**. This time we will let the calculator find the line of best fit. Press **STAT CALC LinReg(ax+b)** 2<sup>nd</sup> stat  $\blacktriangle$  You will see an L type **YEAR**, 2<sup>nd</sup> stat  $\blacktriangle$  You will see an L type **HMEN** and press **enter**

50b. What is your line of best fit? \_\_\_\_\_

- **NN.** Repeat for plots3. **Turn off PLOT 1** and **turn off Y2** (Put the cursor on the + and press enter) and **turn on plot 3** and **graph it**. This time we will let the calculator find the line of best fit. Press **STAT CALC LinReg(ax+b)** 2<sup>nd</sup> stat  $\blacktriangle$  You will see an L

type **YEAR**, 2<sup>nd</sup> stat  $\epsilon$   $\blacktriangle$  You will see an L type **AWOME** and press **enter**

50c. What is the equation of the lines of best fit?

---



---

51. Are your lines of best fit good predictors? Why or Why not?

---



---

52. Predict the wages for all three groups for 2010 and 2015

---



---

53. Which group has the largest annual increase in wages?

---

**PART 2** You will now split up into groups and compare and contrast different groups, such as men from each ethnicity, women from each or everybody from each. You will do as many different comparisons as you can and draw the best conclusions possible for your data.



## Appendix G

### Permission to Use Material

Peoples Education, Inc.

New Jersey Department of Education

Amsco

Peoples Education, Inc.  
 Permission to Use Questions

Dear Joy:

You have permission from Peoples Education to use questions from Unit 3 from the product mentioned below. This permission is granted for only the purpose stated below.

If you have any questions, please contact me.

Sincerely,

Kristine Liebman

Director of Permissions

Peoples Education, Inc.

201-712-0090 ext. 225

**Joy Brokes**

show details Jul 17

Reply to kliebman

Measuring Up Grade 11 NJ ISBN 1-4138-0481-0

Questions from unit 3, both multiple choice and open ended

These questions will be used in my pre- and Post-tests from the instructional unit I am developing for my Doctoral Dissertation

Thank you for your consideration

I am a doctoral student at Montclair State University and I teach at Passaic County Technical Institute

New Jersey Department of Education  
Permission to Use Questions

Good Morning Joy:

I received a forwarded email concerning the use of the HSPA questions from the NJPEP site. You can feel free to use the questions in your pre and post tests as long as you don't alter the questions. Also, the questions from our site can't be used in a fee-based situation. In other words, you can't charge anyone to use the questions.

Best wishes on the completion of your doctorate. Have a great weekend.

Dorothy Atkins  
NJPEP (New Jersey Professional Education Port)  
New Jersey Department of Education  
Phone No.: 609-292-5276  
Fax: 609-943-5202

-----Original Message-----

From: Kubinski, Diane  
Sent: Thursday, July 10, 2008 10:00 AM  
To: 'jbrokes@pcti.tec.nj.us'  
Cc: Kubinski, Diane; Rogers-Lazdins, Lorraine; Peters, Timothy; Atkins, Dorothy; DOETesting; Tubman, JoAnne  
Subject: RE: Other

Thank you for your 7/8/08 e-mail to the Department from the Parents Circle website.

You requested permission to use questions from the NJ PEP site. I am referring you to Dorothy Atkins of the NJPEP office via this e-mail.

In reference to your request to adapt questions from the released 2001 HSPA, it is unclear as to why this would be done. Overall, it is not recommended following reasons:

1. The items were developed in alignment with the Core Content Curriculum Standards and the New Jersey HSPA Directory of Test Specifications to assure content validity.
2. Committees of New Jersey educators reviewed these items for approval.
3. The items were field tested and brought before the committees again based on a statistical review of each item field tested.
4. All of the items were reviewed for bias by a Sensitivity Committee.

All of the above steps are included in the development of the HSPA questions.

I hope this information helps you.

Amsco

Permission to Use Questions

Hi Joy Brokes,

We here by giving permission to use a series of questions per your revised request dated August 10, 2008 as follows:

TITLE = PREPARING FOR THE NEW JERSEY HSPA GRADE 11

ISBN # = 1-56765-544-0

PAGES : 118 # 4, 118 # 6, 121 # 9, 126 # 5, 128 # 3, 128 # 5, 135 # 3, 136 # 10, 140 # 4, 140 # 5, 143 # 18, 144 # 21, 166 # 4, 167 # 4, 169 # 27.

The permission is just to use the above referred questions only and no other questions or pages may be used at all.

Thank you,

Prat Menon

Clerical & Research Administrator.