Effects of Computer Troubleshooting on Elementary Students' Problem Solving Skills

Anne Todd Ottenbreit
Western Michigan University

Follow this and additional works at: https://scholarworks.wmich.edu/masters_theses

Part of the Elementary Education Commons, and the Instructional Media Design Commons

Recommended Citation
https://scholarworks.wmich.edu/masters_theses/3372
EFFECTS OF COMPUTER TROUBLESHOOTING ON ELEMENTARY STUDENTS’ PROBLEM SOLVING SKILLS

by

Anne Todd Ottenbreit

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Master of Arts
Department of Educational Studies

Western Michigan University
Kalamazoo, Michigan
August 2003
EFFECTS OF COMPUTER TROUBLESHOOTING ON ELEMENTARY STUDENTS’ PROBLEM SOLVING SKILLS

Anne Todd Ottenbreit, M.A.
Western Michigan University, 2003

The lack problem solving skills exhibited by students has generated concerns at national and state levels of education (Coleman, King, and Ruth, 2001). If the educational technology curriculum involved computer troubleshooting, students could possibly increase their problem solving abilities. Because computer troubleshooting follows similar procedures to problem solving, there is possibility of an educational transfer and could be easily included into the educational technology curriculum. The purpose of the research study was to discover if the computer troubleshooting curriculum designed by the researcher affected the elementary students’ problem solving abilities. Technology education at the elementary level includes keyboarding and ‘practice and drill’ software. The proposed curriculum would be a new method to meet national technology and math standards of education. Positive outcomes of the research will validate its use in a technology education program.
Copyright by
Anne Todd Ottenbreit
2003
ACKNOWLEDGMENTS

The process of my master's degree was far more difficult than I had anticipated. I was very fortunate to have three excellent committee members to collaborate with throughout that process. First, I would like to thank Dr. Poole. The experience, wisdom, support, understanding and friendship were extremely helpful and very appreciated all the way through the process. I have benefited educationally from having Dr. Poole as my advisor and chair of my committee. I am also grateful to Dr. Bosco, who was especially helpful in challenging my thoughts and ideas in order to produce a better product. I am also grateful to Dr. Leneway who was especially helpful and flexible throughout the entire process.

I would like to also thank both of my parents who offered, love and support throughout my entire Master's process. I would especially like to thank my mother for her endless proofreading and assistance with my master’s research project. My father encouraged me to pursue my topic of interest and assisted in the design process with great passion. My grandparents, sister, brother and the rest of my entire family were very supportive and helpful throughout my master’s degree.

I would also like to thank Dr. Newlin-Haus for all of her assistance with my research design, statistical help and instruction on research methods. The HSIRB sub-committee was extremely instrumental in designing my research design. Mary-Jane Mielke was extremely supportive in my educational technology development throughout the year, and inspired me to become a better educator.

I was very fortunate to conduct my research project at Haigh Elementary School. I would also like to thank Kids Domain.Com and CompTIA for assistance in
Acknowledgments—continued

curriculum. Western Michigan University was extremely helpful and provided three computers for the study.

I would lastly like to thank my best friend Luke for making my life happier, simpler and less stressful through the entire process.

Anne Todd Ottenbreit
TABLE OF CONTENTS

ACKNOWLEDGMENTS ................................................................................................................. ii
LIST OF TABLES ......................................................................................................................... xiii
LIST OF FIGURES ......................................................................................................................... xvii

CHAPTER

I. INTRODUCTION TO THE PROBLEM ................................................................................ 1

Introduction ............................................................................................................................. 1

General Statement of the Problem ......................................................................................... 2

Research Questions and Hypothesis ......................................................................................... 2

Research Hypothesis ............................................................................................................... 2

Major Research Question ........................................................................................................ 2

Minor Research Questions and Hypotheses ............................................................................. 2

Question and Hypothesis 1 ....................................................................................................... 2

Question and Hypothesis 2 ....................................................................................................... 3

Question and Hypothesis 3 ....................................................................................................... 3

Question and Hypothesis 4 ....................................................................................................... 4

Question and Hypothesis 5 ....................................................................................................... 4

Question and Hypothesis 6 ....................................................................................................... 5

Question and Hypothesis 7 ....................................................................................................... 5

Purpose of the Study ............................................................................................................... 6
List of Tables - continued

Background .............................................................................................. 7
Summary .................................................................................................. 7

II. REVIEW OF LITERATURE ........................................................................... 9

Introduction ........................................................................................... 9
Problem Solving Importance ................................................................... 9
Mathematical Problem Solving ............................................................. 10
Michigan Curriculum Mathematical Standards ........................................ 11
Typical Fifth Grade Problem Solving ............................................... 12
Various Math Problem Solving Methods ............................................. 12
Problem Solving and Hands-On Learning .......................................... 13
Problem Solving and Authentic Learning ............................................ 14
Transfer of Problem Solving Skills ...................................................... 14

Introduction .......................................................................................... 14
Scientific Inquiry .................................................................................. 15
Mathematics ....................................................................................... 15
Reading Recovery ................................................................................ 15
Computer Programming and Computer-Based Simulations ............ 15
Technology Education .......................................................................... 16
List of Tables - continued

Groups and Learning in Technology ............................................ 18
Technology and Hands-On Learning ..................................................... 20
Technology and Authentic Learning .................................................... 18
Problem Solving and Computer Troubleshooting .................................. 19

III. METHODOLOGY ......................................................................................... 21

Introduction ............................................................................................ 22
Research Setting .................................................................................... 22

Introduction ................................................................................... 22
Haigh Elementary School Demographics and Area ..................... 22
School Information ....................................................................... 23
Curriculum .................................................................................... 24

Technology Curriculum .................................................... 24
Math Curriculum .............................................................................. 25
Research Design ............................................................................. 28
Computer Troubleshooting Curriculum ................................................ 29

A+ Curriculum.............................................................. 30
Kids Domain Computer Lessons .................................................. 32
Instructional Method.............................................................. 32
Subjects.................................................................................................. 33

Criteria for Students in the Control Group ................................... 34
Criteria for Students in the Experimental Group........................... 35
List of Tables - continued

Variables ...................................................................................................35
Dependent Variables ..............................................................................35
Treatment .................................................................................................35
Subject Selection Factors .............................................................35
Attendance .............................................................................................35
Problem Solving Skills .........................................................................36
Gender ......................................................................................................36

Independent Variables ...........................................................................38
Testing Procedures .................................................................................38
ETS Testing Services ...........................................................................40
IOWA Math Tests .....................................................................................40
POPS Problem Solving Test ...........................................................42
Hands-On Problem Solving Tests ..................................................45
Survey ......................................................................................................47
Group Interview .....................................................................................48
Troubleshooting Activity ......................................................................49

Data Analysis ..........................................................................................50
Hypothesis 1 ............................................................................................50
Hypothesis 2 ............................................................................................51
List of Tables - continued

Hypothesis 3 ................................................................. 51
Hypothesis 4 ................................................................. 52
Hypothesis 5 ................................................................. 52
Hypothesis 6 ................................................................. 52
Hypothesis 7 ................................................................. 53
Summary .................................................................................. 53

A. FINDINGS .............................................................................. 55

Introduction .............................................................................. 55
Explanation of Student’s Profile ............................................. 55
Profile of Each Student’s Assessment Data ......................... 58

Female ....................................................................................... 58

Student 1 Control ............................................................... 58
Student 2 Experimental ....................................................... 60
Student 3 Control ............................................................... 62
Student 4 Experimental ....................................................... 64
Student 5 Control ............................................................... 66
Student 6 Experimental ....................................................... 68

Male ......................................................................................... 70

Student 7 Control ............................................................... 70
Student 8 Experimental ....................................................... 72
Student 9 Control ............................................................... 74
<table>
<thead>
<tr>
<th>Table Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student 10 Experimental</td>
<td>76</td>
</tr>
<tr>
<td>Student 11 Control</td>
<td>78</td>
</tr>
<tr>
<td>Student 12 Experimental</td>
<td>80</td>
</tr>
<tr>
<td>Description of Findings Pertinent to Hypothesis</td>
<td>81</td>
</tr>
<tr>
<td>Hypothesis 1</td>
<td>81</td>
</tr>
<tr>
<td>Troubleshooting Activity</td>
<td>82</td>
</tr>
<tr>
<td>Station #1</td>
<td>83</td>
</tr>
<tr>
<td>Station #2</td>
<td>84</td>
</tr>
<tr>
<td>Station #3</td>
<td>85</td>
</tr>
<tr>
<td>Station #4</td>
<td>85</td>
</tr>
<tr>
<td>Station #5</td>
<td>87</td>
</tr>
<tr>
<td>Station #6</td>
<td>87</td>
</tr>
<tr>
<td>Station #7</td>
<td>88</td>
</tr>
<tr>
<td>Group Interview</td>
<td>89</td>
</tr>
<tr>
<td>Hypothesis 2</td>
<td>91</td>
</tr>
<tr>
<td>POPS- Profiles of Problem Solving Test</td>
<td>91</td>
</tr>
<tr>
<td>Hands-on Problem Solving Test</td>
<td>93</td>
</tr>
<tr>
<td>Hypothesis 3</td>
<td>98</td>
</tr>
<tr>
<td>POPS- Profiles of Problem Solving Test</td>
<td>98</td>
</tr>
<tr>
<td>Survey/Group Interview</td>
<td>99</td>
</tr>
<tr>
<td>Hypothesis 4</td>
<td>101</td>
</tr>
</tbody>
</table>
List of Tables - continued

IOWA Test ................................................................. 101
Group Interview ...................................................... 102
Hypothesis 5 ................................................................. 102
POPS- Profiles of Problem Solving Test ..................... 103
Hands-on Problem Solving Test ................................ 109
Hypothesis 6 ................................................................. 112
POPS- Profiles of Problem Solving Test ..................... 113
Hands-on Problem Solving Test ................................ 117
Hypothesis 7120
POPS- Profiles of Problem Solving Test ..................... 121
Hands-on Problem Solving Test ................................ 125
Group Interview ...................................................... 129
V. CONCLUSION AND RECOMMENDATIONS ......................... 134
Introduction ............................................................. 134
Summary of the Study .................................................. 135
Summary of the Research Problem ............................... 135
Summary of the Methods .............................................. 135
Summary of the Findings .............................................. 136
Hypothesis 1 ............................................................. 136
Hypothesis 2 ............................................................. 137
Hypothesis 3 ............................................................. 139
List of Tables - continued

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>139</td>
</tr>
<tr>
<td>5</td>
<td>140</td>
</tr>
<tr>
<td>6</td>
<td>141</td>
</tr>
<tr>
<td>7</td>
<td>143</td>
</tr>
<tr>
<td>Conclusions</td>
<td>144</td>
</tr>
<tr>
<td>Conclusion of Hypothesis 1</td>
<td>144</td>
</tr>
<tr>
<td>Conclusion of Hypothesis 2</td>
<td>146</td>
</tr>
<tr>
<td>Conclusion of Hypothesis 3</td>
<td>147</td>
</tr>
<tr>
<td>Conclusion of Hypothesis 4</td>
<td>148</td>
</tr>
<tr>
<td>Conclusion of Hypothesis 5</td>
<td>149</td>
</tr>
<tr>
<td>Conclusion of Hypothesis 6</td>
<td>150</td>
</tr>
<tr>
<td>Conclusion of Hypothesis 7</td>
<td>151</td>
</tr>
<tr>
<td>Recommendations for Further Research</td>
<td>153</td>
</tr>
<tr>
<td>Final Conclusions</td>
<td>157</td>
</tr>
</tbody>
</table>

BIBLIOGRAPHY ............................................................................................... 159

APPENDICES

A. Human Subjects Institutional Review Board .............................................. 163
B. Student Assent Form .................................................................................. 165
C. Parental Permission Slip (Letter A) ......................................................... 167
D. Parental Consent Form (Letter B) ............................................................. 170
E. Additional Information Requested By Parents ....................................... 172
List of Tables - continued

F. Cover Sheets for Tests ................................................................. 175
G. Survey ....................................................................................... 177
H. Interview .................................................................................... 180
I. Code Sheet ................................................................................ 182
J. Observation Rubric of Hands-On Problem Solving Test .......... 184
K. Group Interview and Survey Response ...................................... 187
L. Survey and Interview Rubric ..................................................... 192
M. IOWA Test Review ................................................................. 194
N. POPS Test Review ................................................................. 197
O. Hands-On Problem Solving Test .............................................. 199
P. Curriculum for Computer Troubleshooting Training Sessions .... 202
Q. Procedure to Obtain Consent .................................................. 204
R. Master's Thesis Timeline ......................................................... 206
S. Paired Samples T-Test Results ................................................ 209
T. Michigan Curriculum Frameworks ......................................... 214
U. Typical 5th Grade Problem Solving by NTCM ......................... 218
V. Email Documentation from Kids Domain.com .......................... 221
W. Spreadsheet of Answers for Worksheets and Worksheet Samples 223
LIST OF TABLES

3.1. Pre-Testing and Post-Testing Organization ...........................................53
4.1a. Example Table of the Columns Explained in Table A ...........................56
4.1b. Example Table of the Columns Explained in Table B ...........................56
4.1c. Example Table of the Columns Explained in Table C ...........................57
4.1d. Example Table of the Columns Explained in Table D ...........................58
4.2a. Student Identification and IOWA Results ............................................59
4.2b. Easy Hands-On Problem Solving Results ............................................59
4.2c. Difficult Hands-On Problem Solving Results ........................................59
4.2d. POPS- Profiles of Problem Solving ....................................................60
4.3a. Student Identification and IOWA Results ............................................61
4.3b. Easy Hands-On Problem Solving Results ............................................61
4.3c. Difficult Hands-On Problem Solving Results ........................................61
4.3d. POPS- Profiles of Problem Solving ....................................................62
4.4a. Student Identification and IOWA Results ............................................63
4.4b. Easy Hands-On Problem Solving Results ............................................63
4.4c. Difficult Hands-On Problem Solving Results ........................................63
4.4d. POPS- Profiles of Problem Solving ....................................................64
4.5a. Student Identification and IOWA Results ............................................65
4.5b. Easy Hands-On Problem Solving Results ............................................65
4.5c. Difficult Hands-On Problem Solving Results ........................................65
4.5d. POPS- Profiles of Problem Solving ....................................................66
List of Tables - continued

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.6a</td>
<td>Student Identification and IOWA Results</td>
<td>67</td>
</tr>
<tr>
<td>4.6b</td>
<td>Easy Hands-On Problem Solving Results</td>
<td>67</td>
</tr>
<tr>
<td>4.6c</td>
<td>Difficult Hands-On Problem Solving Results</td>
<td>67</td>
</tr>
<tr>
<td>4.6d</td>
<td>POPS- Profiles of Problem Solving</td>
<td>68</td>
</tr>
<tr>
<td>4.7a</td>
<td>Student Identification and IOWA Results</td>
<td>69</td>
</tr>
<tr>
<td>4.7b</td>
<td>Easy Hands-On Problem Solving Results</td>
<td>69</td>
</tr>
<tr>
<td>4.7c</td>
<td>Difficult Hands-On Problem Solving Results</td>
<td>69</td>
</tr>
<tr>
<td>4.7d</td>
<td>POPS- Profiles of Problem Solving</td>
<td>70</td>
</tr>
<tr>
<td>4.8a</td>
<td>Student Identification and IOWA Results</td>
<td>71</td>
</tr>
<tr>
<td>4.8b</td>
<td>Easy Hands-On Problem Solving Results</td>
<td>71</td>
</tr>
<tr>
<td>4.8c</td>
<td>Difficult Hands-On Problem Solving Results</td>
<td>71</td>
</tr>
<tr>
<td>4.8d</td>
<td>POPS- Profiles of Problem Solving</td>
<td>72</td>
</tr>
<tr>
<td>4.9a</td>
<td>Student Identification and IOWA Results</td>
<td>73</td>
</tr>
<tr>
<td>4.9b</td>
<td>Easy Hands-On Problem Solving Results</td>
<td>73</td>
</tr>
<tr>
<td>4.9c</td>
<td>Difficult Hands-On Problem Solving Results</td>
<td>73</td>
</tr>
<tr>
<td>4.9d</td>
<td>POPS- Profiles of Problem Solving</td>
<td>74</td>
</tr>
<tr>
<td>4.10a</td>
<td>Student Identification and IOWA Results</td>
<td>75</td>
</tr>
<tr>
<td>4.10b</td>
<td>Easy Hands-On Problem Solving Results</td>
<td>75</td>
</tr>
<tr>
<td>4.10c</td>
<td>Difficult Hands-On Problem Solving Results</td>
<td>75</td>
</tr>
<tr>
<td>4.10d</td>
<td>POPS- Profiles of Problem Solving</td>
<td>76</td>
</tr>
<tr>
<td>4.11a</td>
<td>Student Identification and IOWA Results</td>
<td>77</td>
</tr>
<tr>
<td>4.11b</td>
<td>Easy Hands-On Problem Solving Results</td>
<td>77</td>
</tr>
<tr>
<td>4.11c</td>
<td>Difficult Hands-On Problem Solving Results</td>
<td>77</td>
</tr>
</tbody>
</table>
List of Tables - continued

4.11d. POPS- Profiles of Problem Solving ........................................................ 78
4.12a. Student Identification and IOWA Results .............................................. 79
4.12b. Easy Hands-On Problem Solving Results ............................................. 79
4.12c. Difficult Hands-On Problem Solving Results ......................................... 79
4.12d. POPS- Profiles of Problem Solving ........................................................ 79
4.13a. Student Identification and IOWA Results .............................................. 80
4.13b. Easy Hands-On Problem Solving Results ............................................. 81
4.13c. Difficult Hands-On Problem Solving Results ......................................... 81
4.13d. POPS- Profiles of Problem Solving ........................................................ 81
4.14. Computer Troubleshooting Activity Results .......................................... 82
4.15. Excerpt From Group Interview - Transcribed Conversation .................. 90
4.16. Control Group Methods Used Section .................................................... 91
4.17. Experimental Group Methods Used Section ........................................... 92
4.18. Time Results from the Easy Problem in the Hands-on Pre- and Post-Test ........................................................ 95
4.19. Control Students’ Pre-Test and Post-Test Ability to Solve the Difficult Problem in the Hands-On Problem Solving Test ........................................................ 96
4.20. Experimental Students’ Pre-Test and Post-Test Ability to Solve the Difficult Problem in the Hands-On Problem Solving Test ........................................................ 96
4.21. Each Student’s Pre-Test Score on the POPS test Graded on Beginning, Developing or Advanced Levels of Achievement ........................................................ 99
List of Tables - continued

4.22. Student Responses to the Most Difficult Problem Solving Process ........................................................ 100

4.23. Mean of POPS Pre-Test vs. Post-Test Total Score Comparing Females vs. Males ......................................... 103

4.24. Comparison of the Methods Used and Extracting Information Categories of the POPS Test Between Mean Gender Score ............................................................................... 104

4.25. Gender Comparisons Divided by Group of Total POPS Score on the Pre- and Post-Tests .................................. 105

4.26. Time Completion Compared by Problem Solving Ability for the Easy Problem in the Hands-On Problem Solving Pre-Test versus Post-Test ...................................................... 118

4.27. Percentage of Students within their Teacher-Rated Problem Solving Ability Groups who solved the difficult problem in the hands-on pre-test versus the post-test ........................................................ 119

4.28. POPS Correctness of Answer, Accuracy and Quality of Explanation Categories Pre-Test and Post-Test Scores Compared Between Ability Groups ........................................... 124

4.29. Results from Easy Problem in Hands-on Problem Solving Test Comparing between Groups ...................................................... 126

4.30. Average Number of Attempts in Control Group versus Experimental Group and Percentage of Each Group Able to Correctly Solve the Difficult Problem ........................................... 128

4.31. Excerpt from Group Interview – Transcribed Conversation ........................................................ 131
LIST OF FIGURES

2.1. The Problem Solving Processes Used as Standard for the Purposes of this Research Study ................................................... 12

3.1. The 48128 Zip Code Dearborn Ethnic Representation ................................................... 23

3.2. Students Ethnic Background at Haigh Elementary School ................................................... 24

3.3. The Dearborn School District’s Current Technology Curriculum ................................................... 26

3.4. Timeline of the Training Sessions ................................................... 29

3.5. Primary Objectives from the CompTIA A+ Curriculum ................................................... 31

3.6. POPS Test Results Compared Between POPS Administrative Test and the Computer Troubleshooting Study Students ................................................... 37

3.7. ETS Services Disclaimer ................................................... 41

3.8. IOWA Test of Basic Skills Review ................................................... 42

3.9. POPS – Profiles of Problem Solving Review ................................................... 46

4.1. Control Group Methods Used Section Graphed ................................................... 92

4.2. Experimental Group Methods Used Section Graphed ................................................... 93

4.3. Comparing Differences of Groups with Number of Attempts in the Hands-On Pre-Test versus Post-Test ................................................... 94

4.4. Time Results from the Easy Problem in the Hands-on Pre- and Post-Test ................................................... 95

4.5. Comparing the Number of Students in Each Group not Able to Solve Correctly or Solve Incorrectly the Difficult Problem in the Hands-On Problem Solving Test ................................................... 97

4.6. Comparing the Number of Students in Each Group Able to Correctly Solve the Difficult Problem in the Hands-On Problem Solving Test ................................................... 97
List of Figures—continued

4.7. IOWA Scores Compared Between Mean Group Scores on the Pre-Test versus the Post-Test ................................................................. 101

4.8. Mean of POPS Pre-Test vs. Post-Test Total Score Comparing Females vs. Males .................................................................................. 104

4.9. Comparison of the Methods Used and Extracting Information Categories of the POPS Test Between Mean Gender Score .............................................................. 105

4.10. Percentage Improvement Between the Pre-Assessment and Post-Assessment of the Total POPS Score Separated by Gender and Group ................................................................. 106

4.11. Difference Between POPS Pre-Assessment and Post-Assessment Score on the Correctness of Answer Category Separated by Gender ........................................................................ 107

4.12. Difference Between POPS Pre-Assessment and Post-Assessment Score on the Accuracy Category Separated by Gender ................................................................. 107

4.13. Difference Between POPS Pre-Assessment and Post-Assessment Score on the Quality of Explanation Category Separated by Gender ........................................................................ 108


4.15. Experimental Females versus Control Females Time to Complete the Easy Problem in the Hands-On Pre-Test and Post-Test ........................................................................ 110

4.16. Difference in Number of Attempts Between the Easy Problem in the Hands-On Pre-Test and Post-Tests Separated by Groups and Gender ........................................................................ 111
List of Figures—continued

4.17. Difference in Number of Attempts Between the Difficult Problem in the Hands-On Pre-Test and Post-Tests Separated by Groups and Gender ......................................... 111

4.18. POPS Total Score Pre-Test and Post-Test Divided by Teacher Rated Problem Solving Ability and Groups .................................................. 114

4.19. POPS Total Score Pre-Test and Post-Test High Teacher Rated Problem Solving Ability Separated by Groups .......................................................... 114

4.20. POPS Total Score Pre-Test and Post-Test Medium Teacher Rated Problem Solving Ability Separated by Groups ............................................. 115

4.21. POPS Total Score Pre-Test and Post-Test Low Teacher Rated Problem Solving Ability Separated by Groups ................................................. 116

4.22. Time Completion Compared by Problem Solving Ability for the Easy Problem in the Hands-On Problem Solving Pre-Test versus Post-Test ..................................... 117

4.23. Number of Attempts on the Easy Problem in the Hands-on Pre-Test versus Post .......................................................... 119

4.24. Difference in Total POPS Score Between the Pre-Test and Post-Test of Average Experimental Group versus Average Control Group ................................................ 121

4.25. Comparing the Difference in POPS Extracting Information Section Pre-Test and Post-Test Between Groups ......................... 123


4.27. Comparing the Percentage of Students in the Control Group versus the Experimental Group Able to Solve the Difficult Problem in the Pre-Test and Post-Test ................................................. 127
CHAPTER 1

INTRODUCTION TO THE PROBLEM

Introduction

The lack of higher level thinking skills used by students has become an area of concern at national and state levels of education (Coleman, King, and Ruth, 2001). Computer troubleshooting contains similar characteristics to problem solving. A technology curriculum encompassing computer troubleshooting has the possibility to enhance the educational technology curriculum, while increasing problem solving ability in elementary students (MacPherson, 1998). The purpose of the research study was to establish whether the computer troubleshooting curriculum designed by the researcher had the ability to affect elementary students' problem solving ability. Technology education at the elementary level has primarily consisted of keyboarding and 'practice and drill' software. Computer troubleshooting and technology have lacked integration at the elementary level (Poris, 2000). Evidence acquired from this research will lend credence to the possible incorporation of this type of training program in order to enhance the learning experience and technology education program.
General Statement of the Problem

Students are currently lacking adequate learning opportunities in problem solving (Coleman, et al, 2001; Jonassen, 2000). Providing students content knowledge is important in the present, but providing students with problem-solving skills is essential for the future. The importance of problem solving is illustrated in the quote, “Give a man a fish; you have fed him for today. Teach a man to fish; and you have fed him for a lifetime”—Author unknown. By teaching students how to solve problems as opposed to supplying them with content knowledge, students will be able to successfully solve life problems, and therefore be successful in life (Casey & Tucker, 1994).

Research Questions and Hypothesis

Research Hypothesis

The use of a computer troubleshooting curriculum as a model for problem solving will improve elementary students’ problem solving abilities.

Major Research Question

Will using a computer troubleshooting curriculum improve elementary students’ problem solving abilities?

Minor Research Questions and Hypotheses

Question and Hypothesis 1

Can elementary students who participate in a computer troubleshooting curriculum develop the ability to solve common computer problems?
Elementary students who participate in a computer troubleshooting curriculum will develop the ability to solve common computer problems by participating in computer troubleshooting trainings.

Students have the ability to retain large amounts of knowledge at the elementary level. Information retrieved from the computer troubleshooting activity and team worksheets were evaluated to establish whether students were able to solve common computer problems. The group interview also provided additional information from transcribed conversation excerpts.

**Question and Hypothesis 2**

Can elementary students who participate in the computer troubleshooting curriculum improve their problem solving methods?

Elementary students who participate in the computer troubleshooting curriculum will improve problem solving methods.

This hypothesis was evaluated through the comparison of the POPS Methods Used section pre-test and post-test results. The hands-on problem solving test was also analyzed to evaluate whether problem solving methods improved.

**Question and Hypothesis 3**

What aspect of problem solving is the most difficult for elementary students?

The most difficult procedure in problem solving for elementary students will be to understand what the question is looking for.
The most difficult procedure in problem solving was initially analyzed through a review of literature and articles. Data was collected through the Profiles of Problem Solving test and the surveys/interviews in order to analyze the most difficult procedure. The standardized problem solving test, POPS, divided the evaluation into five separate categories; Correctness of Answer, Methods Used, Accuracy, Extracting Information and Quality of Explanation. Pre-test scores on each of these categories were compared to find the weakest area. Data was also collected from the Survey/Group Interview, providing information on students’ opinions of the most difficult procedures in the problem solving process.

**Question and Hypothesis 4**

Can elementary students who participate in a computer troubleshooting curriculum increase mathematical problem solving ability?

Elementary students who participate in a computer troubleshooting curriculum will increase mathematical problem solving ability.

The IOWA Basic Skills Test and the Group Interview were used to assess mathematical problem solving ability. Comparisons between the pre-test and post-test IOWA scores of each group were analyzed. Responses from the group interview pertaining to math were also collected for evaluation.

**Question and Hypothesis 5**

Does gender impact the problem solving ability of elementary students involved in a computer troubleshooting curriculum?
Gender will not impact the problem solving ability of elementary students involved in a computer troubleshooting curriculum.

Gender differences were compared through the POPS total scores, individual categories within the POPS test and the hands-on problem solving test. Comparisons between genders and between the experimental and control groups of genders were analyzed using pre-test scores and post-test scores.

**Question and Hypothesis 6**

Does teacher-rated problem solving ability impact the problem solving ability of elementary students involved in a computer troubleshooting curriculum?

Students who participate in a computer troubleshooting curriculum rated by teachers as having high problem solving ability will demonstrate greater improvements in problem solving ability.

Students in the experimental group and control group were matched based on teacher-rated problem solving ability. When students were divided into teacher-rated problem solving groups, the results presented a different angle on improvements. Problem solving ability groups were compared through the POPS total scores, individual categories within the POPS test and the hands-on problem solving test.

**Question and Hypothesis 7**

Can elementary students who participate in a computer troubleshooting curriculum demonstrate greater improvements in problem solving ability than students who did not participate in the program?
Elementary students who participate in a computer troubleshooting curriculum will demonstrate greater improvements in problem solving ability than students who did not participate in the program.

The results from the POPS test, the hands-on problem solving test and the group interview were evaluated in order to establish whether students in the experimental group achieved higher results in the post assessment than the students in the control group. Data was also collected and analyzed from each section of the POPS test.

Purpose of the Study

The main purpose of this project was to examine the problem-solving requirements necessary in computer repair and troubleshooting, and its effect on academic achievement and problem solving. Learning activities such as computer LOGO programming have the ability to develop problem solving skills and improve academic achievement (Kurland, 1986). This project used computer repair and troubleshooting as a model for teaching problem solving strategies. The research study proposed to increase problem solving abilities and academic achievement through computer troubleshooting and repair training. With this research, elementary schools may incorporate the training program into the educational technology program in order to enhance the learning. This program has the potential to inform the educational community of whether computer troubleshooting had an effect on problem solving skills. The training session, if proved effective, could provide a new addition to technology education programs at the elementary level.
Background

At this time of this study, no current research on the proposed topic was found. Computer troubleshooting and repair had been attempted at the high school level with great success, but no relationship to problem solving skills had been tested or proposed. With the present technical focus of today, students need to have the ability to solve everyday problems with technology. The researcher believes that technology education could include computer problem solving as a means of meeting two separate parts of the curriculum; the students would be improving their problem solving skills, while preparing for the future and learning an authentic, meaningful lesson. Therefore, the research would establish baseline data for instructional practices, and further research in this area of education.

Summary

The lack problem solving skills exhibited by students has generated concerns at national and state levels of education (Coleman, King, and Ruth, 2001). If the educational technology curriculum involved computer troubleshooting, students could possibly increase their problem solving abilities. Because computer troubleshooting follows similar procedures to problem solving, there is possibility of an educational transfer and could be easily included into the educational technology curriculum. The purpose of the research study was to discover if the computer troubleshooting curriculum designed by the researcher affected the elementary students’ problem solving abilities. Technology education at the elementary level includes keyboarding
meet national technology and math standards of education. Positive outcomes of the research will validate its use in a technology education program.
CHAPTER II

REVIEW OF LITERATURE

Introduction

“Your problem may be modest; but if it challenges your curiosity and brings into play your inventive faculties, and if you solve it by your own means, you may experience the tension and enjoy the triumph of discovery. Such experiences at a susceptible age may create a taste for mental work and leave their imprint on mind and character for a lifetime” (Wilson, Fernadez & Hadaway, 1993, Ch. 4).

Problem Solving Importance

The purpose of education is to prepare students for success in life. Problem solving skills allow students the opportunity to solve problems that arise in everyday situations. Therefore, problem solving skills are important to include in the curriculum because of their application towards success and life (Jonassen, 2000; Lee 1996). Students need to develop problem solving skills in order to be a successful individual in society and educational institutions are responsible for this preparation (Lee, 1996).
every individual. Coleman, King, and Ruth state "by not challenging students, nor encouraging them to use higher order thinking skills, educators underestimate their students' abilities and delay meaningful grade-level work, as well deprive them of a significant environment for learning" (2001, p.9-10). Currently, students are not receiving adequate learning opportunities to problem solve (Coleman, et al, 2001).

Mathematical Problem Solving

There are many possible methods of teaching problem solving, such as learning to read and scientific discovery. Most schools, however, make little attempt to provide students with the assistance they need to learn a broad range of problem solving strategies. Instead, most schools tend to use formal training in problem solving restricted to the area of mathematics (Poris, 2000).

Mathematics is synonymous with problem solving in education. An effortless method most teachers use to integrate problem solving into the curriculum has been through the creation of story problems. The National Council of Teachers of Mathematics (1989) presents problem solving as one of the most vital skills for students. The New Jersey Board of Education believes "problem posing and problem solving involve examining situations that arise mathematics and other disciplines and in common experiences, [and] by developing their problem solving skills, students will come to realize the potential usefulness of mathematics in their lives" (as reported in Poris, 2000, p.1). Problem solving in mathematics should not be limited to traditional word problems, but should be taught through methods of inquiry and application in order to expose the students to the multiple facets of problem solving.
Mathematical problem solving follows the same requirements for basic problem solving; defining the problem, gathering the relevant information, establishing a strategy or plan, carrying out the plan, and reflecting on the process. As reported in multiple studies, when students are able to perfect this process in mathematics, they will be able to apply the same process to other problems with success (Poris, 2000).

**Michigan Curriculum Mathematical Standards**

The Michigan Curriculum Frameworks are curriculum standards developed by parents, educators, business leaders and university professors. The frameworks listed descriptions of learning objectives students should achieve in subject areas. The mathematics section states the following:

"A mathematically powerful individual should be able to: reason mathematically; communicate mathematically; problem solve using mathematics; and, make connections within mathematics and between mathematics and other fields" (Michigan Department of Education, 2003).

Problem solving is a key benchmark the Michigan Department of Education expects students to meet. A list of the Michigan Curriculum Frameworks pertaining to problem solving can be found in Appendix T.
Typical Fifth Grade Problem Solving Ability

The National Council of Teachers of Mathematics Students indicated that problem solving in grades 3 through 5 should have frequent experiences with problems that interest, challenge, and engage them in thinking about important mathematics. The NCTM declares problem solving as a process that should develop from mathematics and provide a framework in which concepts and skills are learned (NCTM, 2000). The NCTM website presents various problem solving activities that are educationally appropriate for fifth grade students and document the processes the students utilize to solve them (See Appendix U).

Various Problem Solving Methods Used

There are multiple problem solving strategies used by students when attempting to solve a problem. The problem solving methods that will be utilized in this research project consists of four basic steps: (a) understanding the problem; (b) planning a solution; (c) solving the problem and (d) looking back.

Figure 2.1

The Problem Solving Processes Used as Standard for the Purposes of this Research Study

<table>
<thead>
<tr>
<th>UNDERSTAND THE PROBLEM</th>
<th>Look at the problem.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Have you seen a similar problem before?</td>
</tr>
<tr>
<td></td>
<td>If so, how is this problem similar? How is it different?</td>
</tr>
<tr>
<td></td>
<td>What facts do you have?</td>
</tr>
<tr>
<td></td>
<td>What do you know that is not stated in the problem?</td>
</tr>
</tbody>
</table>
| PLAN A SOLUTION | How have you solved similar problems in the past?  
| | What strategies do you know? 
| | Try a strategy that seems as if it will work. 
| | If it doesn't, it may lead you to one that will. 
| SOLVE THE PROBLEM | Use the strategy you selected and work the problem. 
| LOOK BACK | Reread the question. 
| | Did you answer the question asked? 
| | Is your answer in the correct units? 
| | Does your answer seem reasonable? 

Strategies may vary in name, however, most fall into one of the following basic categories: (a) compute or simplify, (b) use a formula, (c) make a model or diagram, (d) make a table, chart or list, (e) guess, check and revise, (f) consider a simpler case, (g) eliminate and (h) look for patterns (Math Counts, 1999).

Problem Solving and Hands-On Learning

Problem solving requires manipulation of the problem by approaching it from various perspectives. Students should be encouraged to use multiple forms of representation, such as symbolic and linguistic representations in order to solve problems. Whether the problem is achieved with mental abilities or external physical depiction, problem solving involves some form of manipulation (Jonassen, 2000; Bodner and Domin, 2000). The ancient Chinese philosopher Lao Tzu illustrates the influence of hands-on learning on the learning process through the statement, “What I hear I forget, what I see I recall, what I do I know” (Waetjen, 1996).
Problem Solving and Authentic Learning

Ill-structured problems are the everyday problems individuals encounter on a regular basis and are the most difficult to prepare students to solve. The solutions are neither easy nor predictable, requiring the individual to use multiple processes in order to resolve them. The best way to prepare students for ill-structured problems is to equip them with problem solving skills through the practice of well-structured problems. Students need to utilize, implement and apply problem solving strategies and content knowledge in order to solve familiar everyday problems (Howard, McGee & Shin, 2001). Real world situations allow students to develop a profound understanding of substance area learning. Problem-based learning environments have shown higher results in achievement than the traditional curriculum environments (Howard, McGee & Shin, 2001). Through the provision of real-world learning experiences, student-led investigations produce "favorable dispositions, a sense of valuing and often a desire to learn more" (Howard, McGee & Shin, 2001, 52).

Transfer of Problem Solving Skills in Subjects to General Problem Solving

Introduction

Problem solving has been incorporated in multiple subject areas to increase abilities in problem solving, and in specific subject area. Problem solving has been integrated into mathematics curriculums, science curriculums, as well as other subjects areas.
Scientific Inquiry

Scientific inquiry emulates the problem solving process. In scientific inquiry studies, students were required to evaluate the problem, brainstorm possible solutions and solve the problem. Through questioning, immediate feedback and investigation, students are able to form their own knowledge on the topic by solving the problem (Taconis, Fergusson-Hessler, & Broekamp, 2000).

Mathematics

Through a meta-analysis, Hembree (1992) found problem solving performance correlated with verbal achievement and mathematic achievement on multiple levels. When mathematical problem solving was tested for transfer effects on other subject areas, computer programming and strategy games were found to be significant (Hembree, 1992).

Reading Recovery

Elementary curriculums have introduced such programs as Reading Recovery to provide students with the ability to solve their own reading difficulties through a heuristic similar to problem solving. Studies using Reading Recovery have shown success in reading with the problem solving heuristic (Wayne & Johnstone, 1997).

Computer Programming and Computer-Based Simulations

Computer programming activities, such as LOGO, provide physical objects, in an abstract form for students to manipulate in order to solve a problem (Hembree, 1992). Studies have also shown that computer problem-based multimedia software
increases understanding and the use of problem-based concepts (Sherwood, 2002). Other computer related activities, such as web-based activities and computer simulation activities, demonstrate an improvement in creative problem solving achievements (Michael, 2001).

Technology Education

Technology education is rapidly becoming one of the most essential elements in today's schools, mainly due to its ability to integrate into the educational curriculum.

Technology Standards for Students

Standards are an important part of curriculum development. The computer troubleshooting curriculum used in the research project was designed to meet the ISTE Profiles for Technology Literate Students and the Michigan Curriculum Framework Standards for Technology. The Michigan Curriculum Framework Standards for Technology requires students to be able to apply appropriate technologies to critical thinking, creative expression, and decision-making skills. The frameworks also require students to employ a systematic approach to technological solutions by using resources and processes to create, maintain, and improve products, systems, and environments.

The ISTE, International Society for Technology in Education, organization devised standards of technology education for elementary through high school students. The organization divided the standards by grades levels. The performance objectives for students include: (1) basic operations and concepts, (2) social, ethical,
and human issues, (3) technology productivity tools, (4) technology communications tools, (5) technology research tools and (6) technology problem-solving and (7) decision-making tools. Many of the performance objectives at the third through fifth grade level demanded problem solving ability, indicating the importance of problem solving within the technology education curriculum.

Technology Influence on Learning

Due to the recent outburst in educational technology and lack of research, a conclusion on the influences technology has on education is yet to be established. However, in the majority of studies reviewed that argued against positive effects of technology (Goldman, Cole & Syer, 1999; Chaika, 1999; Wenglinsky, 1998) lacked a curriculum or specific purpose. Computers and technology have a variety of educational applications and uses within the curriculum. Previously, computers and technology were seen as personal management tools, drill-and-practice machines or graphical image producers. However, computers are now being seen as powerful tools that can enhance and assist the learning process (Poris, 2000).

Gender and Technology

The research concerning gender differences and technology varied in favoring females and males. Computer achievement, attitudes, and anxiety were multiple areas of gender differences. However, no conclusion has been widely accepted as to which gender benefits more from technology (Burge, 2001; Hackbarth, 2002; Fey, 2001; King, Bond & Blandford, 2002; Tsai, 2002).
Groups and Learning in Technology

“Evidence indicates that when used effectively, technology can encourage collaborative learning, development of critical thinking skills, and problem solving” (Coleman, King, Ruth, 2001, p.10). Technology also has the ability to facilitate questioning, feedback, reflection and revision for students when they learn collaboratively. Allowing students to learn collaboratively with technology creates a scaffolding environment where the students are teaching one another (Driscoll, 2002).

Technology and Hands-On Learning

Computers and technology engage students due to hands-on interaction. Most students are excited to use the technology, and therefore, look forward to learning with technical equipment (Waetjen, 1993). Students are able to demonstrate more effort and process material at a more meaningful level when they are interested and believe that they have the ability to solve the problem. Computer repair and troubleshooting are perfect examples of hands-on learning experiences, allowing students to interact with the information and receive immediate feedback (Jonassen, 2000).

Technology and Authentic Learning

Research has documented the real-world model of student investigations leads to productive environments and a motivation to engage in more learning experiences (Wonacott, 2001; MacPherson, 1998). “Studies have concluded technological problem-solving is a key tenet of higher order thinking and that technological
problem-solving is, by definition, rooted in real-life or authentic domains” (MacPherson, 1998, p.5). Technology education has a real advantage in terms of authentic learning experience because of its real-world nature. Troubleshooting has become synonymous with problem solving due to the constant problems associated with technology. Problem solving is process that encompasses qualities common to both technological troubleshooting and general problem solving (MacPherson, 1998).

Problem Solving and Computer Troubleshooting

Technology troubleshooting follows the same cognitive pattern as academic problem solving. Both troubleshooting and problem solving require documenting the problem, brainstorming solutions, and then implementing those solutions according to the development of the individual’s own strategies. In most technical problems, the initial problem and desired result are easily established, but the solutions to achieve the end result are often difficult and numerous (Lee, 1996). Students frequently overlook the important steps in problem solving. Technical problems often require these important steps such as; multiple solutions and complete analysis of the problem (Lavonen, Meisalo & Lattu, 2001). Technology troubleshooting requires the ability to diagnose problems and to test out the possible solutions. Teaching problem solving skills through technology education will enable the student to achieve technical literacy, become skilled troubleshooters and enhance problem-solving skills through the authentic, hands-on learning opportunities provided by technology troubleshooting. Jonassen believes “...troubleshooting is among the most common
forms of everyday problem solving” and through a computer troubleshooting curriculum, students could learn these two skills at once (2000, p.73).
CHAPTER III

METHODOLOGY

Introduction

The research project was designed with a control/experimental pre/post test design. The whole study lasted two school weeks, including all testing periods. The purpose of the project was to establish whether computer troubleshooting had an effect on problem solving skills. Each group included three boys and three girls, matched according to their problem solving ability levels as assessed by their teachers. Both groups received pre-assessment including two standardized tests, a hands-on problem solving test, and a survey collecting information from the students on problem solving skills, attitudes and math abilities. Following the two days of pre-testing, the experimental group attended computer troubleshooting training sessions, which were held for forty-five minutes in the morning before school over the course of five days. The control group received no training. Following the training, the students from the control and experimental group were post-tested. The post-assessment included two standardized tests, the hands-on problem solving test and a group interview modeled from the survey. The pre-tests and post-tests were compared through statistical analysis, graphs and tables, as well as focusing on each individual student’s growth in a case study approach.
Research Setting

Introduction

Howard Poole, the principal investigator, is a faculty member in the Educational Studies Department at Western Michigan University. While research will be analyzed at Western Michigan University, the location of the actual study is at Haigh Elementary School, 601 North Silvery Lane, Dearborn, MI 48128. Collaborating investigators included: Anne Ottenbreit, (Western Michigan University, Graduate Assistant EDT 347, Master’s Student), who has used the research in conjunction with her master’s thesis and Sharon Ottenbreit (Dearborn Public Schools), who was present during instructional periods in accordance with compliances through the Dearborn Public Schools. The other expert mentioned later on, Joel Ottenbreit (Ann Arbor Public Schools), has knowledge of the A+ curriculum and a firm understanding of elementary students’ problem solving abilities and processes.

Haigh Elementary School Demographics and Area

The Haigh Elementary community is an upper-middle class socio-economic status community. The area consists of mainly white individuals, however, a large majority of the students within the white demographic are of Arabic descent.
The median household income in Dearborn is $44,560, while the median income for families in Dearborn is $53,060. According to the census survey taken in 1999, twelve percent of the families in Dearborn are below the poverty level (United States Department of Commerce, 2003).

School Information

Haigh Elementary School is one of twenty elementary schools within the Dearborn Public School District. The Dearborn School district is a large district consisting of 17,129 students. Haigh Elementary School consists of 390 students in kindergarten through fifth grade. Four percent of students who attend Haigh Elementary receive free or reduced lunches (GreatSchools Inc, 2003).
All fifth grade students at Haigh currently use one standard mathematics curriculum and one standard technology curriculum. The technology curriculum was designed by Dearborn Public Schools and is implemented throughout the district. The mathematics curriculum currently uses Mathematics Plus as the standard format and textbook for Dearborn Public Schools.

**Technology Curriculum**

Students in the Dearborn School District were operating primarily MacIntosh computers. The training was conducted using Windows-based, IBM-compatible computers and MacIntosh computers. MacIntosh computers operate in a similar manner to IBM-compatible computers, but there is a large difference concerning hardware. MacIntosh computers typically do not allow manipulation of the system, as IBM-compatible computers do.
A survey taken by the Dearborn Public Schools in 1999 collected information regarding the strengths of the current technology education curriculum. More than three-fourths of elementary students (80%) surveyed had a computer at home. A large majority (87%) of the students responded that they enjoyed using computers a lot. According to the teachers, the usage of the computer labs greatly increased from the original survey in 1992 (45%) to the most current survey in 2001 (80%). Students use school computers for educational purposes such as; drawing, painting, writing stories and reports, educational programs, encyclopedia work, the Internet, games, and for CD-ROM reference (K-12 Computer Curriculum Committee, 2001).

The students' prior computer troubleshooting skills were minimal due to a lack of computer experience. The 5\textsuperscript{th} grade curriculum in technology is designed through a number of scopes and sequences.

\textbf{Math Curriculum}

The current curriculum of problem solving involves mathematical story problems based on the fifth grade math book MATHEMATICS PLUS, by Harcourt-Brace and Company. The current math problem solving curriculum is comprised of choosing strategies, methods of computation and operation, conducting simulations, multi-step problems, relevant and irrelevant information and evaluating answers for reasonableness. The curriculum expressed through Mathematics Plus, encompasses several key elements
Figure 3.3

The Dearborn School District’s Current Technology Curriculum

**KNOWLEDGE**

- Verify students’ ability to start and quit applications
- Verify students’ ability to log onto file server
- Verify students’ ability to appropriately care for disks/CD’s
- Reinforce students’ ability to perform a warm start
- Reinforce students’ ability to check cords and cables
- Develop students’ ability to select hardware/software applications for tasks
- Develop students’ ability to describe how technology meets human needs in the home, school, community and workplace
- Develop students’ ability to describe how people create use and control technology
- Develop students’ ability to identify technology related careers
- Develop students’ ability to describe advances in technology and their impact on society
- Develop students’ ability to identify the computer hardware components
- Explore students’ ability to use multimedia software
- Verify students’ ability to understand what the CPU, monitor, keyboard, mouse and data storage drive are
- Reinforce students’ ability to use the printer
- Reinforce students’ awareness of the network versus the stand alone computer
- Develop students’ ability to understand/use special keys (ESC, CTRL, etc…)
- Develop students’ ability to use touch typing method
- Develop students’ ability to know and use icons
- Master students’ ability to understand and use menus, function keys and buttons

**PROBLEM SOLVING**

- Develop students’ ability to identify problems; find ways in which computers can solve problems

**APPLICATION**

*Word Processing*

- Develop students’ ability to manipulate font (size, style, etc…)
- Reinforce students’ ability to print
- Reinforce students’ ability to use spell check, and thesaurus

*Internet*
• Explore students’ ability to use a browser
• Explore students’ ability to enter a site location
• Explore students’ ability to retrieve electronic information
• Explore students’ ability to cite internet references
• Explore students’ ability to demonstrate responsible use of the internet by adhering to the district’s Internet Usage Policy
• Explore students’ ability to use a search engine

**GENERAL SKILLS**

• Develop keyboarding skills
• Verify students’ ability to point/click
• Master/Verify students’ ability to click and drag
• Develop students’ ability to insert/delete
• Develop students’ ability to save
• Develop students’ ability to copy, cut and paste

**SOCIAL AND ETHICAL ISSUES**

• Develop students’ ability to describe the impact of technology on daily lives
• Develop students’ ability to identify ways various technology is used in the home, school, community and workplace
• Develop students’ ability to respect privacy and ownership of individual or organization information or product
• Develop students’ ability to articulate that individuals are responsible for their technological actions and decisions
• Introduce students’ ability to adhere to copyright, patent, and freedom of information laws related to using technology
• Develop students’ ability to describe how technology impacts information, information access, analysis, organization and utilization

students must learn. First, students learned how to use a heuristic, which is a guide for thinking. The textbook promotes the following process; (a) understand the problem, (b) plan a solution, (c) solve the problem, and (d) look back. The curriculum secondly directs students to use different types of problem solving
strategies. The strategies introduced by Mathematics Plus were (a) make and use tables, charts, and graphs; (b) make a list, (c) guess and check, (d) find a pattern, (e) draw and use pictures; (f) make and use models; (g) write a number sentence/equation, (h) work backward, and (i) solve a simpler problem. The curriculum lastly requires the students to communicate the process of problem solving. The textbook concentrates on problem solving in order to allow students to apply the heuristic guide they have learned. The Mathematics Plus textbook includes a problem of the day in every lesson, asking students to apply different skills for various types of problems.

Research Design

The research project measured the difference of students’ ability to problem solve and academic achievement prior to and following the computer troubleshooting curriculum. Measures consisted of students’ scores and performances on the Profiles of Problem-Solving Standardized Test (POPS), IOWA Basic Skills Math Test, the hands-on problem solving test and a group interview following the training sessions. The students’ abilities to solve computer problems were also analyzed. This study was conducted using six students for the experimental group and six students for the control group. The research project used a pre-test/post-test quasi-experimental research design with a control and experimental group. The experimental group received the treatment and both groups were pre-tested prior to the training, and post-tested after the training was complete. The entire project protocol took place at Haigh Elementary School over the course of two weeks. The researcher chose to perform
the study over the course of two weeks in order to reduce the external validity issues associated with the effects of information they gained from school. Subject recruitment started after the HSIRB approval and the beginning of the baseline data collection was initiated on May 12th, 2003. A timeline of the training sessions is presented in figure 3.4.

**Figure 3.4**

Timeline of the Training Sessions

<table>
<thead>
<tr>
<th>Week 1:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1: Pre-Testing</td>
<td></td>
</tr>
<tr>
<td>Day 2: Pre-Testing/Getting to Know You and the Computer</td>
<td></td>
</tr>
<tr>
<td>Day 3: Lesson 1: Outer Hardware, Intro to Hardware on the Inside</td>
<td></td>
</tr>
<tr>
<td>Day 4: Lesson 2: Hardware on the Inside</td>
<td></td>
</tr>
<tr>
<td>Day 5: Lesson 3: Storage, Files and Folders, The Windows Desktop</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Week 2:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1: Lesson 4: Knowing Your System, Programs, Operating Systems, Computer Care and Safety</td>
<td></td>
</tr>
<tr>
<td>Day 2: Lesson 5: Troubleshooting Real Problems</td>
<td></td>
</tr>
<tr>
<td>Day 3: Post-Testing</td>
<td></td>
</tr>
<tr>
<td>Day 4: Post-Testing</td>
<td></td>
</tr>
</tbody>
</table>

**Computer Troubleshooting Curriculum**

The primary purpose of the computer training sessions was to provide students with the experience to apply problem solving methods in an authentic, hands-on manner that would easily transferable to other situations.

The experimental group received the training for forty-five minutes, over the course of two weeks on May 21st, 22nd, 23rd, 27th and 28th. The curriculum was designed and instructed by the researcher. The researcher used a combination of
CompTIA's A+ objectives and Kids Domain computer lessons to create a troubleshooting curriculum conducive to elementary learning. Lesson plans providing detailed information on the training sessions can be found in the Appendix P.

A+ Curriculum

The CompTIA A+ certification is the industry standard for validating vendor-neutral skills expected of an entry-level computer technician. Technicians with A+ certification have a firm knowledge of and competency in computer hardware and operating system including installation, configuration, diagnosing, preventive maintenance and basic networking. A+ certification provides the perfect outline for objectives that must be accomplished in order to affirm successful ability to troubleshoot computers (The Computing Technology Industry Association, Inc, 2002).

The training sessions were designed to mimic the CompTIA manual, but written in a manner conducive to elementary student's ability to learn. The researcher modified the program to meet the needs of elementary students. The training sessions taught students the hardware components of a computer, how to build a computer, how to troubleshoot basic problems associated with hardware and software, and other functions associated with the computer. These learning objectives assisted in the understanding of how a computer functions. A list of primary objectives are available in figure 3.5.
Figure 3.5
Primary Objectives from the CompTIA A+ Curriculum

- Recognize and be able to state the name and purpose of each hardware element as listed below

Motherboard
Power Supply
Processor /CPU
Memory
Storage devices
Monitor
Modem
Peripheral
BIOS
CMOS
LCD (portable systems)
Ports
PDA (Personal Digital Assistant)

- Insert and remove all hardware as specified below

**Examples of modules:**
- Motherboard
- Storage device
- Power supply
- Processor/CPU
- Memory
- Input devices
- Hard drive
- Keyboard
- Video Card
- Mouse
- Network Interface Card (NIC)

**Portable system components:**
- AC adapter
- Digital camera
- PC card
- Pointing devices
- Install and configure hard drives, video cards, printers, processors and memory.
- Diagnose symptoms and problems related to computer hardware.
- Troubleshoot basic hardware problems through typical procedures.
- Use preventative maintenance in order to ensure the safety and upkeep of the technology, themselves and others.
- Use safety procedures in order to ensure the safety and upkeep of the technology, themselves and others.
- Troubleshoot, care for and service printers.
- Indicate which operating system a computer is currently running and the main functions of an operating system.
- Install, configure and upgrade windows XP operating system.
- Install and launch applications.
- Diagnose and troubleshoot basic problems associated with the operating system and applications.

**Kids Domain Computer Lessons**

Kids Domain.Com offers a large variety of child friendly activities and lesson plans. The explanation, organization and presentation of the material was targeted toward elementary students. The curriculum for the computer troubleshooting training sessions was adapted from the Kids Domain website. The researcher contacted the company for permission to use the material, and was granted permission by the company through email. The email documentation can be found in Appendix V.

**Instructional Method**

The students received instruction through hands-on learning experiences; physically installing and troubleshooting main parts of a computer, increasing
knowledge through interaction with the components and problems. The students also received troubleshooting simulations, providing real experience with problem-solving situations. These authentic learning situations supplied students with the opportunity to apply their new skills and solutions, while receiving immediate feedback. The students were given handouts and other supplementary learning tools to enhance learning within the curriculum. The students were instructed through individual, team and whole group settings, providing various formats/strategies of instruction in order to solidify learning concepts. Demonstrations and discussions pertaining to specific problems and different solutions were presented to the whole group. Teams of two students were implemented for all hardware and software installations in order to facilitate questioning and answering between pairs. This configuration was able to fully utilize the equipment to produce the maximum learning experience for the students. Worksheets and individualized instruction were provided in order to further solidify the learning concepts.

Subjects

The subject selection was limited to students who submitted a signed permission slip and parent consent form. Students without these documents completed were not eligible to participate. Out of the students who volunteered to participate in the training, the students were selected using specific criteria. The first disaggregate was gender, due to the vast differences in computer and technical ability found in previous research in relation to gender (Fey, 2001; Frantom, Green & Hoffman, 2002; Suomala & Alajaaski, 2002). The researcher first selected three girls
and three boys for the experimental group and three girls and three boys for the control group. The second disaggregate was based on the students' school attendance record over the past year. Students with a good attendance record were the most desired since absences and tardiness could have affected the end results of the project. The third disaggregate was the level of problem solving abilities. The researcher had the fifth grade teachers rank the students on their problem solving ability; low, medium, and high. The researcher did not attempt to collect any particular scores; rather, the focus of the level of problem solving ability was used to match students between the experimental and control groups. To ensure the lack of favoritism or perception of favoritism in selecting students for the experimental versus the control group, the matched subjects were randomly assigned to groups. Though recruiting a true random sample was extremely unlikely, this procedure achieved the closest random sample approximation possible, given the nature of voluntary participation of students.

Criteria for Students in the Control Group

The student subjects were not selected, as all of the students in the fifth grade were invited to participate. Subjects were volunteers and permission-based participation was required. Students involved in the control group were selected based on; gender, attendance and similar problem solving skills compared to students in the experimental group in order to decrease the possible threats to the validity of the data.
Criteria for Students in the Experimental Group

The student subjects were not selected, as all of the students in the fifth grade were invited to participate. Subjects were volunteers and permission-based participation was required. Students involved in the experimental group were selected based on; gender, attendance and similar problem solving skills to students in the control group in order to decrease the possible threats to the validity of the data.

Variables

**Dependent Variables**

**Treatment**

The computer troubleshooting activity was videotaped to ensure the instructor exhibited no favoritisms or other forms of biases during the sessions. The videotape was viewed and evaluated at a later time by an A+ expert, Joel Ottenbreit. The expert indicated no researcher biases existed.

**Subject Selection Factors**

The subjects were selected based on several dependent variables.

**Attendance**

Attendance was a large factor for selection of subjects. The training sessions contained so much information, it was pertinent that the students attend all training
sessions and were punctual. The teachers were asked to rate the students based on attendance and tardiness over the past semester. All students were rated based on good attendance and number of tardies. The students rated with a high number of tardies and absences were dismissed from the study, in order to decrease as many variables as possible.

**Problem Solving Skills**

The researcher had the fifth grade teachers rate the students’ problem solving abilities as; (a) high, (b) medium, or (c) low. Once subjects with multiple tardies and absences had been dismissed from the project and the research subjects had been separated by problem solving ability, students were matched based on gender.

**Gender**

The researcher selected students based on gender due to the large difference between boys and girls in learning and computer activities. The researcher was able to selected three girls and three boys for each group in order to balance the groups for comparison purposes. The information was collected from the permission slips returned by the students who wanted to participate in the study. The researcher randomly selected three pairs of matched problem solving ability girls and three pairs of matched problem solving ability boys and placed one student from each pair in the experimental group and the other student in the control group.
When the computer troubleshooting study students were compared to the POPS Administrative Test, performed by the testing company involving 371 subjects, the subjects involved in this research project scored lower in the Correctness of Answer, Methods Used and Extracting Information sections. However, they scored higher, on average, in the Accuracy and Quality of Explanation sections, than their peers involved in the POPS Administrative Test. However, most differences were not substantial, and therefore, students chosen were representative of their peers based on the POPS Administrative Test performed by the authors.
Independent Variables and Data Collection Process

There were multiple independent variables which affected the results of this project. For each method of assessment, the students received a code test cover sheet indicating the students’ name, code name and method of assessment (See Appendix I). These measures were for organizational purposes only. The tests and other forms of assessment were identifiable only by code numbers. The master code list was only available to the researchers.

Testing Procedures

Before every test or training, students were read the student assent form, indicating they would receive no extra credit, and even if they agreed to participate they could change their minds at any time throughout the testing or training (See Appendix B). They were also reminded that they were volunteers and were free to stop participating whenever they chose without any penalties for quitting.

Once the method of assessment was completed, the students were instructed to notify the researcher. The researcher would then return the answer sheet and test booklet into a manila folder. The students who finished were given the next assessment until all methods of assessment were completed.

The students completed the IOWA Basic Skills Math Problem Solving and Data Interpretation twenty-six item section of the IOWA test. The mathematical problem solving standardized test took approximately twenty to twenty-five minutes to complete and was conducted in Room 4 of Haigh Elementary School under the
supervision of a Dearborn Public School teacher. The teacher, as well as the researcher, was available to help read the items and answer questions. The researcher read the assent form to the students before testing. To ensure confidentiality, a cover sheet was included listing the student’s name and ID number. The student’s converted ID number was the only form of identification on all assessments. The converted ID number was randomly assigned by the researcher. The code sheet containing the student’s name, student identification number and the test score will be kept in a locked file cabinet in a university office that only researchers will have access to. The researcher explained each test’s instructions, asked the students to complete the standardized tests and raise their hands when finished. As each individual completed the first test, the researcher distributed the second standardized test, POPS, with the code sheet and explained the instructions individually. Once the tests were completed, the assessment was placed in the corresponding folder for organizational purposes. The second problem solving test, POPS, took approximately thirty minutes to complete and was administered in the same manner on the same day. Due to time constraints, the students were able to take two days for pre-testing and two days for post-testing. The tests were collected in the same manner as the first standardized test. Throughout the testing period, students were randomly asked to take the hands-on problem solving test, which was videotaped in the back of the classroom. Once the students had completed all three tests, the students were given a self-assessment survey. However, due to the time constraints of two days for pre-assessment and two days for post-assessment, all students were not able to finished the survey.
ETS Services

The researcher used two of the five evaluation materials from the ETS Test Collection. The Educational Testing Service Test Collection Database allows access to tests according to the following terms of use.

IOWA Basic Math Skills Test

The IOWA Test of Basic Skills Math Problem Solving and Data Interpretation measured the subjects' mathematical problem solving ability. Students in the experimental group and control group both were pre-tested before school in Room 4. The students were given instructions from the IOWA Test of Basic Skills Teacher's Manual. The test took approximately thirty minutes for each student to complete, containing twenty-six questions. The students recorded their answers on a multiple choice standardized testing answer sheet. The answer sheets were collected and scored by the researcher using the IOWA Test of Basic Skills answer key. The data was compared between pre-test and post-test scores to establish differences. In addition, the data will be part of the formative evaluation process to assess effectiveness of program activities and to guide development of future programs.

The researcher chose to use the IOWA Basic Skills Math Test to measure the students' mathematical problem solving ability, due to the recommendation obtained from the Mental Measurements Yearbook Review Online (Figure 3.8). The researcher only used the Math Problem Solving and Data Interpretation section of the test, in order to keep testing time to a minimum. Brief information concerning the
IOWA test is located below, but a full description, including reviews is located in Appendix M.

Figure 3.7

ETS Services Disclaimer

PLEASE READ THESE TERMS OF USE CAREFULLY BEFORE USING THE TEST COLLECTION DATABASE. BY USING THE DATABASE, YOU AGREE TO THESE TERMS OF USE. IF YOU DO NOT AGREE TO THESE TERMS OF USE, PLEASE DO NOT USE THE DATABASE.

"The ETS Test Collection provides microfiche copies of certain unpublished test as a service to educators and psychologists. It is hoped that these materials will provide users with creative ideas for the development of their own instruments, or, in some instances, with measures of attributes for which no published tests are available.

The materials included on the microfiche may be reproduced by the purchaser for his own use until otherwise notified by ETS or the author. Permission to use these materials in any other manner must be obtained directly from the author. This includes modifying or adapting the materials, and selling or distributing them to others. Any copyright notice or credit lines must be reproduced exactly as provided on the original.

Typically, the tests included in this service have not been subjected to the intensive investigation usually associated with commercially published tests. As a consequence, inclusion of a test does not imply any judgment by ETS of the quality or usefulness of the instrument. The purchaser must assume full responsibility for controlling access to these materials, the manner in which they are used, and the interpretation of data derived from their application.

It is recommended that access to these microfiche be limited to students conducting research, staff members of professionally recognized educational and psychological institutions or organizations, and individuals who are members of the American Educational Research Association, the American Psychological Association, the National Council on Measurement in Education, or the Association of Measurement and Evaluation in Guidance. The qualifications of others not in these categories should receive careful consideration.
Finally, the purchaser is urged to provide information about his use of these materials directly to the authors. Many cooperating authors are interested in collecting data on their instruments, which will make them more useful to others. Therefore, it is to the advantage of everyone concerned - authors, present users, and users in the future - that purchasers recognize their professional responsibility to initiate such communication. The address of the author of each instrument as of the date on which the series is released is listed on this notice that appears first on each download test."

(http://testcollection.ets.org/cgi/swebmmu.exe?ini=TESTCOLL&act=3&lang=&uid=public&idck=&eid=&tid=8955229401-0j)

POPS Problem Solving Test

The second standardized test used in order to assess students' ability to process problem solving situations, was the Profiles of Problem-Solving (POPS) Standardized Test. Students began this test after completing the IOWA Basic Math Skills Test and were given individualized instructions for the test from the researcher. The 6-question test took approximately 20-25 minutes for each student to complete and was given in the same room as the IOWA Basic Math Skills. The students recorded their answers on an answer sheet, explaining their answers with drawing, words and number sentences. The answer sheets were collected and scored by the researcher using the POPS Answer Booklet.

Figure 3.8
IOWA Test of Basic Skills Review

Test Name: Iowa Tests of Basic Skills Forms K L and M
Test Author: Hoover-H; D; Hieronymous-A; N; Frisbie-D; A; Dunbar-S; B
Publication Date: 1955-1996
Scores: Vocabulary, Listening, Language, Language Total, Mathematics, Core Total, Word Analysis
A. Purpose
"To provide a comprehensive assessment of student progress in the basic skills."

B. Population
Grades K.1-1.5, K.8-1.9, 1.7-2.6, 2.5-3.5, 3, 4, 5, 6, 7, 8-9, . . . LE-10: 5, 6, 7, 8, 9, 10, 11, 12, 13, 14.

C. Scores

D. Time
(130-310) minutes for Complete Battery; (100) minutes for Survey Battery

E. Comments
Part of Riverside's Integrated Assessment System; Braille and large-print editions available
Test and were given individualized instructions for the test from the researcher. The 6-question test took approximately 20-25 minutes for each student to complete and was given in the same room as the IOWA Basic Math Skills. The students recorded their answers on an answer sheet, explaining their answers with drawing, words and number sentences. The answer sheets were collected and scored by the researcher using the POPS Answer Booklet.

The researcher chose the test due to the recommendation obtained from the Mental Measurements Yearbook Review Online (Figure 3.9). Once the testing agency was contacted in order to purchase the test, the agency informed the researcher the name of the test was changed from the Surveys of Problem Solving (SPRS) to the Profiles of Problem Solving (POPS).

The POPS test divided each student evaluation into five separate categories. The first category, Correctness of Answer, was a measure of whether the answer was correct. The Methods Used category measured the approach used, focusing more on
the plan rather than the calculations. The more systematic plan the student developed, or if the student used a pattern, the higher the score. The Accuracy category measured the ability to calculate, focusing more on the mathematical aspect of problem solving. The Extracting Information category measured the extent to which the student understood the problem, relevant facts and relationships between variables. Lastly, the Quality of Explanation category measured the student’s ability to communicate the problem solving process. Each category was present in multiple questions and graded separately for each student. Every category was divided into three possible levels of achievement; beginning, developing and advanced. Each student was graded on the pre-test and post-test, using the three possible levels.

Brief information concerning the POPS test is located below (See Figure 3.9) but a full description, including reviews is located in the Appendix N.

**Hands-On Problem Solving Test**

Throughout each testing period, students were randomly asked to take the hands-on problem solving test, which was videotaped in the back of the classroom. The researcher allowed students ten minutes to complete two activities. The hands-on problem solving test was videotaped in order to provide evidence of problem solving methods the students used. The researcher reviewed the hands-on problem solving test at a later time, evaluating through the use of the hands-on problem solving rubric (See Appendix J). The hands-on problem solving test was based off of problem solving activities using tangrams. The researcher established two activities for the
### Test Name: Profiles of Problem Solving
**Test Author:** Stacey-Kaye; Groves-Susie; Bourke-Sid; Doig-Brian  
**Publication Date:** 1993  
**Scores:** 5: Correctness of Answer, Method Used, Accuracy, Extracting Information, Quality of Explanation  
**Reviewer:** McLellan-Mary-J; Medina-Diaz-Maria  
**Review Indicator:** 2 reviews available  
**Publisher:** Australian Council for Educational Research 19 Prospect Hill Road Private Bag 55 Camberwell Victoria 3124 Australia  
**Acronym:** POPS  
**Mental Measurements Yearbook:** 13 Mental Measurements Yearbook  
**Accession Number:** 13081532

#### F. Purpose
"An assessment of mathematical problem solving designed for children in upper primary school".

#### G. Population
Grades 4-6.

#### H. Price
1993 price data: $75 per manual and photocopiable masters.

#### I. Administration

- **Group**
- **Scores**

5: Correctness of Answer, Method Used, Accuracy, Extracting Information, Quality of Explanation.

#### J. Scores

- **Manual**

Manual, 1993, 64 pages

#### K. Manual

#### L. Time

[32] 40 minutes

#### M. Comments

researcher established two activities for the hands-on test; an easy and difficult tangram problem. The students had a maximum of five minutes to complete each problem to the best of their ability. The post test each student was given utilized the
same tangram set as the pre test. The book and tangrams used can be found in the Appendix O. Dr. Poole, Sharon Ottenbreit and the three fifth grade teachers assessed the tangram problems, in order to assure the test was at an appropriate level. The test assessed the different methods students used solving hands-on problems requiring manipulation, the amount of time taken to solve the problem and the number of attempts made by the student. The researcher compared data on methods students used to solve problems prior to, as opposed to after the training. The researcher also compared data between the control and experimental groups to see if there was any difference between groups.

Survey.

The student self-assessment surveys gathered the students' perception of their own problem solving abilities and methods they consciously apply to problems. The survey provided information on how students solve problems prior to the training. The surveys also provided a comparison for the group interviews, which followed the training serving as a post test. However, due to time constraints, all of the students could not complete the surveys. The data was part of the process to better design the computer troubleshooting activities and to guide development of future educational technology programs. The survey has been modified from “Student Thinking About Problem Solving Scale”, used in a previous thesis project (Armour, 1986).

The survey was a last priority for pre-assessment and was given to the students if they were able to complete all the tests within the first two days of the project. Therefore, not all students were able to complete the surveys. The survey consisted of
ten questions. The first seven questions used the Likert scale to evaluate how students felt about problem solving and their problem solving ability. The last three questions were short response answers concerning methods they use to solve problems. Surveys included the cover sheet consisting of the student’s name and assigned ID number; only randomly assigned ID number was on the actual survey. Only the researchers had access to the name/ID list. When finished with the survey, the students returned the survey to the researcher. The sample survey, as well as the survey it was adapted from is located in the Appendix G.

**Group Interview**

The researcher conducted the interview as a group interview, due to time constraints. The interview was originally planned as a form of post assessment to the survey, but since all students did not complete the survey, answers were combined from the survey and interview to create a large database of information. Students from the control and experimental group were both present in the same room, at the same time. Each student was supplied with an interview sheet, pencil and clipboard so the interview could be conducted in a circle, on a floor rug. The researcher read each question aloud, and after every child was finished, the students shared their responses with the group. The group interview was videotaped in order to collect all of the anecdotal data contributed through oral conversations. The researcher transcribed the videotape at a later time. As in the survey, the first seven questions were based on a rating likert-scale. The last three questions were short response questions related to problem solving methods. An additional question was added at
the end of the Interview, asking the students' opinions of whether the computer troubleshooting training sessions could make a difference on problem solving abilities. The list of interview questions is attached in the Appendix H.

**Troubleshooting Activity**

The final computer troubleshooting activity was videotaped for additional data. In the troubleshooting activity, the students worked in teams of two on the stations. There were seven stations total for the students to complete. At each station, there was a different problem the students needed to identify, solve/fix and check to see if they accomplished the solution. The students contacted the researcher to verify the completion of a station and the station was then prepared for the next set of students. Each station was equipped with a worksheet for students to record their answers. These worksheets were collected for data. Examples of the worksheets, as well as the spreadsheet of answers to each question can be found in Appendix W.

The videotape and completed worksheets documented the students' ability to solve common computer problems. In addition to this data collected, additional observations from the instructor helped analyze the level of troubleshooting skills.

**Data Analysis**

The data from the standardized tests scores and hands-on problem solving time scores were analyzed along with other factoring variables in order to correctly analyze the data. The results of test scores form a two-by-two design that was analyzed with a Paired-Sample T-Test. The SPSS program was used to compute
analyze the data. The results of test scores form a two-by-two design that was analyzed with a Paired-Sample T-Test. The SPSS program was used to compute correlation statistics, and appropriate t-tests analyses. The computed correlation statistics, mean and standards, percentage frequencies, and correlation coefficients were used to draw inferences from the collected data. However, since samples were so small the results were inconclusive. Comparisons between group scores and student responses were analyzed for disparities and congruencies between their perceptions and scores concerning problem solving. Variables measured through the observation, survey and interview data were also analyzed in conjunction with data from the rest of the database. The ordinal data collected from the hands-on problem solving test scores was analyzed. Data was compared between the control group improvements and experimental group improvements. The surveys and interviews were used to gather information on student problem solving methods and processes. Through the addition of extensive analysis, the researcher expected to be able to make summative evaluation statements regarding the computer training program and estimate the effectiveness on problem solving.

Hypothesis 1

The first hypothesis was that elementary students would acquire the ability to troubleshoot common computer problems successfully. In order to evaluate this hypothesis, three separate collections of data were analyzed. The first data collected and analyzed for hypothesis one was the Troubleshooting Activity. The researcher divided the students up into teams of two and documented the teams as they
attempted to solve the different computer station problems. The researcher documented whether students were able to solve the common computer problems at each station.

Hypothesis 2

The second hypothesis was elementary students involved in the computer troubleshooting curriculum would improve their problem solving methods as compared to student who did not participate. In order to evaluate this hypothesis, two separate collections of data were analyzed. The first data collected and analyzed was the POPS – Profiles of Problem Solving Methods Used section. The research compared pre-test and post-test scores to establish the improvement of each student, as well as average improvements for each group. The researcher also analyzed the hands-on problem solving test, including number of attempts, time completion of the easy problem and the number of students in each group able to solve the different problem.

Hypothesis 3

The research assessed the most difficult procedure in problem solving for elementary students by using findings from the Profiles of Problem Solving test. Each category of the problem solving process was separately analyzed by observing pre-test scores of the students. The second source of findings used to discover the most difficult problem solving procedure was the survey/group interview. The researcher grouped the responses into categories based on key phrases and evaluated the most identified problem.
Hypothesis 4

Information was collected from the IOWA Basic Skills math problem solving and data interpretation test and the group interview, in order to analyze whether mathematical ability would be affected by the training sessions. The IOWA test results were analyzed for the average scores of each group. The group interview provided additional anecdotal data.

Hypothesis 5

Gender differences were evaluated through the Profiles of Problem Solving test and the hands-on problem solving test. The POPS pre-test and post-test total scores were compared between genders, as well as each category of the POPS test. Additional results were collected from the hands-on problem solving test. The researcher compared the completion time for the easy problem from the pre-test to the post-test. The findings for the number of attempts to solve each problem were also studied from the hands-on problem solving test to analyze the affects of gender on the results of the study.

Hypothesis 6

Students classified by teachers as having high, medium and low problem solving abilities were compared to evaluate if the variable was a significant factor. Average improvements in total POPS score for each group were analyzed. The hands-on problem solving test was analyzed for improvement in time completion of the easy problem and the increase in the average number of attempts between the pre-test and the post-test. The number of students able to solve the difficult problem was
also analyzed.

Hypothesis 7

Information from the Profiles of Problem Solving test, the hands-on problem solving test and the survey/interview were all used to investigate the final hypothesis. The mean total POPS score was averaged for each group, comparing the pre-test total score to the post-test total score. The hands-on problem solving test results were evaluated for each group, analyzing information on improvement in time completion of the easy problem, the average number of attempts in both problems from the pre-test to the post-test, and the percentage of students able to solve the difficult problem. The last collection of data analyzed to address the hypothesis was the final group interview. Information from question eleven was an additional source of information.

Summary

Table 3.1

Pre-Testing and Post-Testing Organization

<table>
<thead>
<tr>
<th>Test</th>
<th>Pre/Post</th>
<th>Date</th>
<th>Method of Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>IOWA Math Test</td>
<td>Pre-Test</td>
<td>5/19-5/20</td>
<td>• 26-item test</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Questions correct out of 26</td>
</tr>
<tr>
<td>POPS – Profiles of Problem Solving</td>
<td>Pre-Test</td>
<td>5/19-5/20</td>
<td>• 6-item test</td>
</tr>
<tr>
<td>Standardized Test</td>
<td></td>
<td></td>
<td>• Answers based on POPS Answer Booklet</td>
</tr>
</tbody>
</table>
| Hands-On Problem Solving Test: Tangrams  
*Easy & Difficult Problem* | Pre-Test | 5/19-5/20 | • Attempts  
• Time  
• Solution  
Correct/Incorrect |
| --- | --- | --- | --- |
| Survey | Pre-Test to interview | 5/19-5/20 | • Likert Scale  
• Anecdotal Data |
| POST | POST | POST | POST |
| IOWA Math Test | Post-Test | 5/29-5/30 | • 26-item test  
• Questions correct out of 26 |
| SPRS Problem Solving Standardized Test | Post-Test | 5/29-5/30 | • 6-item test  
• Answers based on POPS Answer Booklet |
| Hands-On Problem Solving Test: Tangrams  
*Easy & Difficult Problem* | Post-Test | 5/29-5/30 | • Attempts  
• Time  
• Solution  
Correct/Incorrect |
| Interview | Post-Test to survey | 5/29-5/30 | • Likert Scale  
• Anecdotal Data |
| Troubleshooting Activity | Post-Test  
*Experimental Only* | 5/28 | • Correct Solutions  
• Able to apply Problem Solving Methods |
CHAPTER IV

FINDINGS

Introduction

Six students participated in five hours of computer troubleshooting training, over the course of two weeks in order to increase their knowledge of computer troubleshooting, thereby improving their ability to solve problems. The prediction for the research project was that over the course of training, the subjects would improve in their ability to solve computer problems. It was further predicted that as the subjects began to improve in their ability to solve computer problems, they would also begin to improve in general problem solving ability. Finally, it was predicted through the comparison of pre and post assessments, students would show evidence of improved achievement in general problem solving and mathematical problem solving achievement.

Explanation of Student’s Profile

Each student’s results are described in a brief profile below. The specific data and information pertinent to each hypothesis is described later on in the chapter. The individual’s profile begins with a description of each student’s demographic information and a short summary of the student’s results. Each student’s summary includes charts of their results on each form of assessment. The first chart describes basic information about the student and their results on the IOWA Basic Skills math problem solving and data interpretation subtest.
Table 4.1a

Example Table of the Columns Explained in Table A.

Student Identification and IOWA Results

<table>
<thead>
<tr>
<th>Student Code Number</th>
<th>Group</th>
<th>Gender</th>
<th>Teacher-Rated Problem Solving Ability</th>
<th>IOWA Pre-Test</th>
<th>IOWA Post-IOWA Difference Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student’s randomly assigned code number (1-12)</td>
<td>Control (C) or Female (F)</td>
<td>Experimental (E)</td>
<td>High, Medium, Low</td>
<td>This is the number of points correct out of 26 on the pre-test</td>
<td>This is the number of points correct out of 26 on the post-test</td>
</tr>
</tbody>
</table>

The second table shows the student’s results on the third part of the Hands-On Problem Solving Test.

Table 4.1b

Example Table of the Columns Explained in Table B.

Easy Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>How many times the student attempted the problem during the pre-test</td>
<td>How many times the student attempted the problem during the post-test</td>
<td>How long it took the student to complete the problem during the pre-test</td>
<td>How long it took the student to complete the problem during the post-test</td>
<td>Whether the student solved the problem during the pre-test</td>
<td>Whether the student solved the problem during the post-test</td>
</tr>
</tbody>
</table>
The third table shows the student’s results on the second part of the Hands-On Problem Solving Test.

Table 4.1c

Example Table of the Columns Explained in Table C.

Difficult Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
</tr>
</thead>
<tbody>
<tr>
<td>How many times the student</td>
<td>How many times the student</td>
</tr>
<tr>
<td>How long it took the student</td>
<td>How long it took the student</td>
</tr>
<tr>
<td>Whether the student solved the problem correctly,</td>
<td>Whether the student solved the problem correctly,</td>
</tr>
<tr>
<td>attempted the problem again during the pre-test</td>
<td>attempted the problem again during the pre-test</td>
</tr>
<tr>
<td>the post-test</td>
<td>the post-test</td>
</tr>
</tbody>
</table>

The final table shows the POPS, Profiles of Problem Solving Test. The test is broken up into five separate sections; Correctness of Answer (COA), Methods Used (MU), Accuracy (A), Extracting Information (EI) and Quality of Explanation (QE). Each of these sections evaluated a different part of problem solving ability and the points total range. The total score is also listed.
Table 4.1d
Example Table of the Columns Explained in Table D.

POPS- Profiles of Problem Solving

COA: Correctness of Answer

MU: Methods Used

A: Accuracy

EI: Extracting Information

QE: Quality of Explanation

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The number of correct points on the pre-test.</td>
<td>The number of correct points on the post-test.</td>
<td>The number of correct points on the pre-test.</td>
<td>The number of correct points on the post-test.</td>
<td>The number of correct points on the pre-test.</td>
<td>The number of correct points on the post-test.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EI: Pre</th>
<th>EI: Post</th>
<th>QE: Pre</th>
<th>QE: Post</th>
<th>Total: Pre</th>
<th>Total: Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>The number of correct points on the pre-test.</td>
<td>The number of correct points on the post-test.</td>
<td>The number of correct points on the pre-test.</td>
<td>The number of correct points on all of the pre-tests.</td>
<td>The number of correct points on all of the post-tests.</td>
<td></td>
</tr>
</tbody>
</table>

Profile of Each Student’s Assessment Data

Female

Student 1 Control

Subject #1 was a female student in the control group, who was rated by her teacher as a high ability problem solver. The student had good attendance throughout
the school year. The student was matched up with student number 6 in the experimental group. The student was shy, quiet and reserved during all periods of assessment. The student stayed constant in the pre and post assessments of the easy hands-on problem solving test, solving both correctly. She also maintained the same number of attempts and the amount of time to complete the difficult hands-on problem solving tests, however, she solved the problem correctly during the post-test. She was the only student to dramatically improve on the IOWA test. The student’s results on the POPS post-test increased in the Correctness of Answer, Accuracy and Extracting Information sections, improving her total POPS score by four points. Below is documentation of her scores throughout the project.

Table 4.2a

Student Identification and IOWA Results

<table>
<thead>
<tr>
<th>Student Group</th>
<th>Gender</th>
<th>Teacher-Rated Problem Solving</th>
<th>IOWA Pre</th>
<th>IOWA Post</th>
<th>IOWA Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>C</td>
<td>F</td>
<td>14</td>
<td>21</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 4.2b

Easy Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1 min</td>
<td>1 min</td>
<td>Solved Correctly</td>
<td>Solved Correctly</td>
</tr>
</tbody>
</table>

Table 4.2c

Difficult Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>Not Solved</td>
<td>Solved Correctly</td>
</tr>
</tbody>
</table>
Table 4.2d
POPS- Profiles of Problem Solving

COA: Correctness of Answer
MU: Methods Used
A: Accuracy
EI: Extracting Information
QE: Quality of Explanation

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>14</td>
<td>18</td>
</tr>
</tbody>
</table>

Student 2 Experimental

Subject #2 was a female student in the experimental group, who was rated by her teacher as a high ability problem solver. The student had good attendance throughout the school year. The student was matched up with student number 5 in the control group. The student was shy, quiet and polite during all periods of assessment. The student participated actively in all computer and troubleshooting activities. The student showed knowledge and understanding of the topic as the training sessions proceeded. The student’s results showed slight differences between the pre and post easy hands-on problem solving test, solving both correctly. She increased the number of attempts on the difficult problem during the post-test, however, she was unable to solve the problem during either test. She was consistent with all of the subjects, improving two points on the IOWA test. The student’s
results on the POPS post-test increased in the Correctness of Answer, Methods Used, Extracting Information and Quality of Explanation sections, improving her total score by ten points. This student’s improvement in the POPS test was the most dramatic of all of the subjects. Below is documentation of her scores throughout the project.

Table 4.3a
Student Identification and IOWA Results

<table>
<thead>
<tr>
<th>Student Group</th>
<th>Gender</th>
<th>Teacher-Rated Problem Solving</th>
<th>IOWA Pre</th>
<th>IOWA Post</th>
<th>IOWA Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 E F High</td>
<td></td>
<td></td>
<td></td>
<td>21</td>
<td>23</td>
</tr>
</tbody>
</table>

Table 4.3b
Easy Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2</td>
<td>2.25</td>
<td>2.5</td>
<td>Solved Correctly</td>
<td>Solved Correctly</td>
</tr>
</tbody>
</table>

Table 4.2c
Difficult Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>Not Solved</td>
<td>Not Solved</td>
</tr>
</tbody>
</table>
Table 4.3d

POPS- Profiles of Problem Solving

COA: Correctness of Answer

MU: Methods Used

A: Accuracy

EI: Extracting Information

QE: Quality of Explanation

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>11</td>
<td>8</td>
<td>12</td>
<td>8</td>
<td>8</td>
<td>6</td>
<td>8</td>
<td>5</td>
<td>6</td>
<td>35</td>
<td>45</td>
</tr>
</tbody>
</table>

Anecdotal Data:

When asked: Do you think that learning how to troubleshoot a computer helped you with your problem solving skills? Why or why not?

Her Response:

“Yes. Because you had to figure out what the problem is and you have to think of the solution of the problem.”

Student 3 Control

Subject #3 was a female student in the control group, who was rated by her teacher as a medium ability problem solver. The student had good attendance throughout the school year. The student was matched up with student number 4 in the experimental group. The student was shy, quiet and reserved during all periods of assessment. The student quickly solved the easy hands-on problem solving post-test, improving her completion time by 30 seconds. During both part of the post-test for
the hands-on problem solving test, the student had fewer attempts on the problem. She also was able to solve the difficult hands-on problem solving tests during the post-test. Her IOWA score improved two points, which was a typical result. The student’s results on the POPS post-test increased in the Correctness of Answer, Methods Used and Extracting Information sections, improving her total POPS score by six points. Below is documentation of her scores throughout the project.

Table 4.4a
Student Identification and IOWA Results

<table>
<thead>
<tr>
<th>Student Group</th>
<th>Gender</th>
<th>Teacher-Rated Problem Solving</th>
<th>IOWA Pre</th>
<th>IOWA Post</th>
<th>IOWA Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>F</td>
<td>Medium</td>
<td>22</td>
<td>24</td>
</tr>
</tbody>
</table>

Table 4.4b
Easy Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1</td>
<td>1.5</td>
<td>1</td>
<td>Solved Correctly</td>
<td>Solved Correctly</td>
</tr>
</tbody>
</table>

Table 4.4c
Difficult Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>Not Solved</td>
<td>Solved Correctly</td>
</tr>
</tbody>
</table>
Table 4.4d

POPS- Profiles of Problem Solving

COA: Correctness of Answer

MU: Methods Used

A: Accuracy

EI: Extracting Information

QE: Quality of Explanation

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>9</td>
<td>7</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>29</td>
<td>35</td>
</tr>
</tbody>
</table>

Student 4 Experimental

Subject #4 was a female student in the experimental group, who was rated by her teacher as a medium-ability problem solver. The student had good attendance throughout the school year. The student was matched up with student number 3 in the control group. The student was outgoing, methodical and confident during all periods of assessment. Although there is no documentation, the researcher believed this student to be the most knowledgeable of computer information prior to the training sessions. The student was occasionally too eager to participate in the hands-on segment of the training and constantly interrupted the instructor to ask questions. The student stayed constant in both parts of the pre- and post- hands-on problem solving test, solving both correctly. She also maintained similar number of attempts and time on the both parts of the pre- and post- hands-on problem solving tests, however, she took more time to solve the difficult part during the post-test. She did
not improve on the IOWA test. The student’s results on the POPS test increased in the Methods Used, Accuracy, Extracting Information and Quality of Explanation sections, while decreasing her scores on the Correctness of Answer section. She improved her total POPS score by nine points. Below is documentation of her scores throughout the project.

Table 4.5a
Student Identification and IOWA Results

<table>
<thead>
<tr>
<th>Student Group</th>
<th>Gender</th>
<th>Teacher-Rated Problem-Solving Ability</th>
<th>IOWA Pre</th>
<th>IOWA Post</th>
<th>IOWA Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>E F</td>
<td>Medium</td>
<td>20</td>
<td>20</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 4.5b
Easy Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1</td>
<td>1.25</td>
<td>1</td>
<td>Solved Correctly</td>
<td>Solved Correctly</td>
</tr>
</tbody>
</table>

Table 4.5c
Difficult Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>Solved Correctly</td>
<td>Solved Correctly</td>
</tr>
</tbody>
</table>
Table 4.5d
POPS- Profiles of Problem Solving

COA: Correctness of Answer
MU: Methods Used
A: Accuracy
EI: Extracting Information
QE: Quality of Explanation

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>5</td>
<td>4</td>
<td>7</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>6</td>
<td>21</td>
<td>30</td>
</tr>
</tbody>
</table>

Anecdotal Data:

When asked: Do you think that learning how to troubleshoot a computer helped you with your problem solving skills? Why or why not?

Her response:

“Yes. Because you learned how to fix things easier when we did the computer. I think yes because we actually learned like, cause you didn’t help us that much. You just kind of took apart the computer and we had to think of all the parts that were missing and stuff. We did it in like art. The printer wasn’t working; it was the same problem here. So we pressed the button and it worked.”

**Student 5 Control**

Subject #5 was a female student in the control group, who was rated by her teacher as a high-ability problem solver. The student had good attendance throughout the school year. The student was matched up with student number 2 in the control
The student was shy, quiet and reserved during all periods of assessment. The student stayed constant in both sections of the pre- and post- hands-on problem solving test. She did use a multiple attempt approach in the easy section of the post-hands-on problem solving test, decreasing her time by one minute and fifteen seconds. Her IOWA score improved one point, which was a typical result. The student's results on the POPS test increased in the Correctness of Answer and Accuracy sections, while decreasing in the Extracting Information, improving her total POPS score by one point. Below is documentation of her scores throughout the project.

Table 4.6a
Student Identification and IOWA Results

<table>
<thead>
<tr>
<th>Student Group</th>
<th>Gender</th>
<th>Problem Solving Rating by IOWA Pre</th>
<th>IOWA Post</th>
<th>IOWA Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>C</td>
<td>F High</td>
<td>21</td>
<td>22</td>
</tr>
</tbody>
</table>

Table 4.6b
Easy Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>2.5</td>
<td>1.25</td>
<td>Solved Correctly</td>
<td>Solved Correctly</td>
</tr>
</tbody>
</table>

Table 4.6c
Difficult Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>Not Solved</td>
<td>Not Solved</td>
</tr>
</tbody>
</table>
Table 4.6d

POPS- Profiles of Problem Solving

COA: Correctness of Answer

MU: Methods Used

A: Accuracy

EI: Extracting Information

QE: Quality of Explanation

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>27</td>
<td>28</td>
</tr>
</tbody>
</table>

Student 6 Experimental

Subject #6 was a female student in the experimental group, who was rated by her teacher as a high-ability problem solver. The student had good attendance throughout the school year. The student was matched up with student number 1 in the control group. The student was shy, quiet and reserved during all periods of assessment. During the training sessions, the student would not volunteer at first. The instructor would ask student #6 for an answer, and usually the student would know the answer. The student was meek, but willing to take part in the hands-on aspect of the training, being easily pushed aside by other students. The student was one of the most improved students in the pre- and post- hands-on problem solving test. On both tests, she was able to improve her time and solved the difficult section during the post-test. She improved two points on the IOWA test, which was a typical result of the subjects. The student’s results on the POPS test increased in the Correctness of Answer, Methods Used and Accuracy sections, while decreasing in
Quality of Explanation section. The student improved her POPS total score by six points. Below is documentation of her scores throughout the project.

Table 4.7a
Student Identification and IOWA Results

<table>
<thead>
<tr>
<th>Student Group</th>
<th>Gender</th>
<th>Problem Solving Rating by IOWA Pre</th>
<th>IOWA Post</th>
<th>IOWA Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>E</td>
<td>F</td>
<td>High</td>
<td>20</td>
</tr>
</tbody>
</table>

Table 4.7b
Easy Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3</td>
<td>1.75</td>
<td>1.25</td>
<td>Solved Correctly</td>
<td>Solved Correctly</td>
</tr>
</tbody>
</table>

Table 4.7c
Difficult Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2</td>
<td>5</td>
<td>4.5</td>
<td>Not Solved</td>
<td>Solved Correctly</td>
</tr>
</tbody>
</table>
Table 4.7d

POPS- Profiles of Problem Solving

COA: Correctness of Answer

MU: Methods Used

A: Accuracy

EI: Extracting Information

QE: Quality of Explanation

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>11</td>
<td>6</td>
<td>8</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>5</td>
<td>4</td>
<td>33</td>
<td>39</td>
</tr>
</tbody>
</table>

Anecdotal Data:

When asked: Do you think that learning how to troubleshoot a computer helped you with your problem solving skills? Why or why not?

Her response:

“I think it helped by learning strategies like in math.”

Male

Student 7 Control

Subject #7 was a male student in the control group, who was rated by his teacher as a low-ability problem solver. The student had good attendance throughout the school year. The student was matched up with student number 12 in the experimental group. The student was quiet, reserved and rushed through all periods of assessment. The student’s results were similar in the pre- and post- hands-on problem solving test. He felt pressured by the other student completing before him
problem solving test. He felt pressured by the other student completing before him and gave up on the difficult section of the test. He had more attempts during the pre-tests of both parts than in the post-tests. He notified the instructor he had finished, when he had never completed the difficult problem. He improved on the IOWA test by three points, which was a typical score with the subjects. The student’s results on the POPS test decreased in the Correctness of Answer, Methods Used, Accuracy and Quality of Explanation sections, decreasing his total POPS score by six points. The researcher believes the reason for the decrease is due to rushed efforts. Below is documentation of his scores throughout the project.

Table 4.8a

Student Identification and IOWA Results

<table>
<thead>
<tr>
<th>Student Group</th>
<th>Gender</th>
<th>Problem Solving Rating by Teachers</th>
<th>IOWA Pre</th>
<th>IOWA Post</th>
<th>IOWA Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers</td>
<td>C M</td>
<td>Low</td>
<td>14</td>
<td>17</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 4.8b

Easy Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>2</td>
<td>1.5</td>
<td>1.25</td>
<td>Solved Correctly</td>
<td>Solved Correctly</td>
</tr>
</tbody>
</table>

Table 4.8c

Difficult Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>2</td>
<td>4.75</td>
<td>1.75</td>
<td>Solved Incorrectly</td>
<td>Solved Incorrectly</td>
</tr>
</tbody>
</table>
Table 4.8d
POPS- Profiles of Problem Solving

COA: Correctness of Answer
MU: Methods Used
A: Accuracy
EI: Extracting Information
QE: Quality of Explanation

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>17</td>
</tr>
</tbody>
</table>

Student 8 Experimental

Subject #8 was a male student in the experimental group, who was rated by his teacher as a high-ability problem solver. The student had good attendance throughout the school year. The student was matched up with student number 9 in the experimental group. The student was interested, quiet and well-behaved during all periods of training and assessment. The student asked intelligent questions and volunteered multiple answers during group discussions. The student improved in both sections of the post- hands-on problem solving test. He was able to solve the problem in the difficult section of the post-test, which he was not able to successfully complete in the pre-test. His completion time on both the easy section and the difficult section also improved in the post-test. His score on the IOWA test did not change, which was typical for all subjects. The student’s results on the POPS test increased in the Correctness of Answer, Methods Used, Accuracy and Extracting
Information sections, improving his total POPS score by nine points. Below is documentation of his scores throughout the project.

Table 4.9a
Student Identification and IOWA Results

<table>
<thead>
<tr>
<th>Student Group Gender</th>
<th>Problem Solving Rating by IOWA Pre</th>
<th>IOWA Post</th>
<th>IOWA Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers E M High</td>
<td>23</td>
<td>23</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 4.9b
Easy Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>4.75</td>
<td>4</td>
<td>Solved Correctly</td>
<td>Solved Correctly</td>
</tr>
</tbody>
</table>

Table 4.9c
Difficult Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>5</td>
<td>4.75</td>
<td>Not Solved</td>
<td>Solved Correctly</td>
</tr>
</tbody>
</table>
Anecdotal Data:

When asked: Do you think that learning how to troubleshoot a computer helped you with your problem solving skills? Why or why not?

His response:

"Yes I think troubleshooting will make a difference because finding out what's wrong with a computer is a lot like finding out what the solution is in a question. I had to figure out what was wrong with the computer. And it was a lot like trying to figure out the problem."

**Student 9 Control**

Subject #9 was a male student in the control group, who was rated by his teacher as a high-ability problem solver. The student had good attendance throughout the school year. The student was matched up with student number 8 in the experimental group. The student was energetic, rambunctious and rushed during all periods of assessment. The student had a good attitude and sought out attention in
The student solved the easy section faster in post-hands-on problem solving test than in the pre-test. The student solved the difficult section problem correctly in the pre-test, but was unable to solve the problem in the post-test. He received the same score on the IOWA pre-test as he did on the IOWA post-test. The student’s results on the POPS test decreased in every section, decreasing the total POPS score by 8 points total. Below is documentation of his scores throughout the project.

### Table 4.10a
Student Identification and IOWA Results

<table>
<thead>
<tr>
<th>Student Group</th>
<th>Gender</th>
<th>Problem Solving Rating by Teachers</th>
<th>IOWA Pre</th>
<th>IOWA Post</th>
<th>IOWA Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers</td>
<td>C M</td>
<td>High</td>
<td>20</td>
<td>20</td>
<td>0</td>
</tr>
</tbody>
</table>

### Table 4.10b
Easy Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>.5</td>
<td>1</td>
<td>Solved Correctly</td>
<td>Solved Correctly</td>
</tr>
</tbody>
</table>

### Table 4.10c
Difficult Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>4</td>
<td>4.75</td>
<td>5</td>
<td>Solved Correctly</td>
<td>Not Solved</td>
</tr>
</tbody>
</table>
Student 10 Experimental

Subject #10 was a male student in the experimental group, who was rated by his teacher as a high-ability problem solver. The student had good attendance throughout the school year. The student was matched up with student number 11 in the control group. The student was unmotivated, quiet and reserved during all periods of assessment and training. The student stayed consistent many aspects of both sections of the pre- and post- hands-on problem solving test. He maintained similar attempts, times and solved the easy section correctly in the pre and post-tests. However, he solved the difficult section during the pre-test, but was unable to complete the problem during the post-test. There was noise and distractions during his hands-on problem solving post-test. He improved his IOWA score by 3 points, which is a typical improvement. The student’s results on the POPS test increased in the Methods Used and the Quality of Explanation sections, while decreasing in the
Correctness of Answer sections. The student improved his total POPS score by one point. Below is documentation of his scores throughout the project.

Table 4.11a
Student Identification and IOWA Results

<table>
<thead>
<tr>
<th>Student Group</th>
<th>Gender</th>
<th>Problem Solving Rating by Teachers</th>
<th>IOWA Pre</th>
<th>IOWA Post</th>
<th>IOWA Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers</td>
<td>E</td>
<td>High</td>
<td>16</td>
<td>19</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 4.11b
Easy Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>4</td>
<td>4.25</td>
<td>4</td>
<td>Solved Correctly</td>
<td>Solved Correctly</td>
</tr>
</tbody>
</table>

Table 4.11c
Difficult Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>Solved Correctly</td>
<td>Not Solved</td>
</tr>
</tbody>
</table>
Table 4.11d

POPS- Profiles of Problem Solving

COA: Correctness of Answer

MU: Methods Used

A: Accuracy

EI: Extracting Information

QE: Quality of Explanation

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>7</td>
<td>7</td>
<td>2</td>
<td>3</td>
<td>22</td>
<td>23</td>
</tr>
</tbody>
</table>

Student 11 Control

Subject #11 was a male student in the control group, who was rated by his teacher as a high-ability problem solver. The student had good attendance throughout the school year. The student was matched up with student number 10 in the experimental group. The student was outgoing and well-behaved during all periods of assessment. He was the first to finish every test. The student took less time to complete the easy section of the hands-on problem solving test. He was unable to solve the difficult problem in the pre- and post- hands-on problem solving test. He improved his IOWA score by one point, which is typical of all the subjects. The student’s results on the POPS test increased in the Correctness of Answer and Extracting Information sections, improving his total POPS score by five points. Below is documentation of his scores throughout the project.
Table 4.12a
Student Identification and IOWA Results

<table>
<thead>
<tr>
<th>Student Group</th>
<th>Gender</th>
<th>Problem Solving Rating</th>
<th>IOWA Pre</th>
<th>IOWA Post</th>
<th>IOWA Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers</td>
<td></td>
<td>High</td>
<td>22</td>
<td>23</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 4.12b
Easy Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1</td>
<td>1.25</td>
<td>.5</td>
<td>Solved Correctly</td>
<td>Solved Correctly</td>
</tr>
</tbody>
</table>

Table 4.12c
Difficult Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>Not Solved</td>
<td>Not Solved</td>
</tr>
</tbody>
</table>

Table 4.12d
POPS- Profiles of Problem Solving

COA: Correctness of Answer
MU: Methods Used
A: Accuracy
EI: Extracting Information
QE: Quality of Explanation

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>10</td>
<td>7</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>6</td>
<td>8</td>
<td>3</td>
<td>3</td>
<td>31</td>
<td>36</td>
</tr>
</tbody>
</table>
Student 12 Experimental

Subject #12 was a male student in the experimental group, who was rated by his teacher as a low-ability problem solver. The student had good attendance throughout the school year. The student was matched up with student number 7 in the control group. The student was quiet and reserved during all periods of assessment and training. The student was motivated to begin the training and was excited by the hands-on aspect of the training. The student was classified as Learning Disabled. The student improved his time in the easy section of the hands-on problem solving test. He was also able to solve the difficult problem correctly during the post-test, as opposed to the pre-test. He improved his score on the IOWA test by three points, which is typical of the students within this study. The student’s results on the POPS test increased in the Methods Used and Accuracy sections, but decreased in the Correctness of Answer and Extracting Information sections. His overall POPS total score decreased by one point. Below is documentation of his scores throughout the project.

Table 4.13a
Student Identification and IOWA Results

<table>
<thead>
<tr>
<th>Student</th>
<th>Group</th>
<th>Gender</th>
<th>Problem Solving Rating by</th>
<th>IOWA Pre</th>
<th>IOWA Post</th>
<th>IOWA Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Teachers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>E</td>
<td>M</td>
<td>Low</td>
<td>16</td>
<td>19</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 4.13b
Easy Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
</table>
Table 4.13c

Difficult Hands-On Problem Solving Results

<table>
<thead>
<tr>
<th>Pre: Attempts</th>
<th>Post: Attempts</th>
<th>Pre: Time</th>
<th>Post: Time</th>
<th>Pre: Solution</th>
<th>Post: Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>Not Solved</td>
<td>Solved Correctly</td>
</tr>
</tbody>
</table>

Table 4.13d

POPS- Profiles of Problem Solving

COA: Correctness of Answer

MU: Methods Used

A: Accuracy

EI: Extracting Information

QE: Quality of Explanation

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>6</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>18</td>
<td>17</td>
</tr>
</tbody>
</table>

Description of Findings Pertinent to Hypothesis

Hypothesis 1

Elementary students can develop knowledge through computer troubleshooting in order to solve common computer problems.
Troubleshooting Activity

The final troubleshooting activity was set-up in seven stations. At each station, there was a separate computer problem the students were required to solve. The students were separated into teams of two and were given a sheet for each station. The student would then assess the problem, fix the problem and describe the solution on the worksheet. The students solved all problems they encountered (See Table 4.14).

Table 4.14

Computer Troubleshooting Activity Results

<table>
<thead>
<tr>
<th>Station Number</th>
<th>Station Title</th>
<th>Problem</th>
<th>Team 1 Solution</th>
<th>Team 2 Solution</th>
<th>Team 3 Solution</th>
</tr>
</thead>
</table>
| #1             | Printer on the Mac | Main Source: Printer  
Specifics: No Paper, Power Off, Power Cable to Printer, Cable from Computer to Printer, Power Cable to Power Strip | Solved All      | Solved All      | Solved All      |
| #2             | MAC Number Two     | Main Source: Program Installation  
Specifics: Mouse/Keyboard Unplugged from Computer, Computer Program Installation | Solved All      | Solved All      | Unable to Stop at Station due to Time Constraints |
| #3             | Open Box with a Black Screen | Main Source: Monitor  
Specifics: Power Cable for Monitor, Power On, Power Cable for Tower | Solved All      | Solved All      | Solved All      |
Table 4.14 – continued

<table>
<thead>
<tr>
<th>#4</th>
<th>What’s Wrong with this Box?</th>
<th>Main Source: Minor Pieces removed/unplugged Specifics: Mouse Trackball removed, RAM removed, Monitor Unplugged from Tower, Sound unplugged from Card</th>
<th>Solved All</th>
<th>Solved All</th>
<th>Solved All</th>
</tr>
</thead>
<tbody>
<tr>
<td>#5</td>
<td>Example Box</td>
<td>This was an example box. No problem was presented here.</td>
<td>Visited</td>
<td>Did not Visit</td>
<td>Did not Visit</td>
</tr>
<tr>
<td>#6</td>
<td>Laptop Trauma</td>
<td>Main Source: Missing File Specifics: Change the desktop picture</td>
<td>Solved All</td>
<td>Solved All</td>
<td>Solved All</td>
</tr>
<tr>
<td>#7</td>
<td>Trouble with Laptop Printing</td>
<td>Main Source: Printer Driver/Installation Specifics: Laptop was missing printer software/driver</td>
<td>Solved All as one group, due to time constraints.</td>
<td>Solved All as one group, due to time constraints.</td>
<td>Solved All as one group, due to time constraints.</td>
</tr>
</tbody>
</table>

Station #1

At station #1, titled “Printer on the Mac”, the printer was the main source of the problem. The specific problems with the printer were: the printer was lacking paper, the power was turned off, the power cable was not connected to the printer, the cable from computer to the printer was not connected and the power cord was not plugged into the power strip. Teams wrote the following responses:
Team #1: “Plug in printer and put in paper.”

Team #2: First it wasn’t plugged in and the USB wasn’t plugged in. There was no paper. The printer was not plugged in to the [monitor].”

Team #3: “What’s wrong with your printer is the plug wasn’t in and there was no paper. So you need to put some in.”

All three teams solved all the problems successfully without guidance from the instructor. All teams printed a document after correcting the problems, and presented it to the instructor.

Station #2

At station #2, titled “MAC Number Two”, the students were required to install a program. However, the mouse and keyboard were both unplugged. The students needed to first correct this problem, and then move on to install the program. Each group received a different program to install because the removal of each program would have taken too much time. Teams wrote the following responses:

Team #1: “Plug in any plugs, put in CD and pushed yes, You put the CD in and clicked on yes to install it.”

Team #2: “One problem we had was the mouse was not plugged in. We first went to installer then we pushed continue and it installed them. We restarted the computer.”

Team #3: Did not complete due to time constraints.
Only two groups completed this station due to time constraints. All teams successfully installed a program after connecting the peripheral devices. The instructor checked each installation.

**Station #3**

At station #3, titled “Open Box with a Black Screen”, the students were required to fix minor problems with the monitor. The monitor power cable was unplugged, the power button on the monitor was turned off, and the monitor cable was not plugged into the system tower. Teams wrote the following responses:

Team #1: “Monitor won’t turn on because it had no power and it was not plugged in to the power tower.”

Team #2: “The monitor is not working. It is not working because the [monitor] is not plugged into the power tower.”

Team #3: “[The problem is the] monitor won’t turn on because the power cable isn’t plugged into the monitor.”

All three teams solved all the problems correctly without guidance or clarification from the instructor. All teams successfully turned on the monitor after correcting the problems, and presented the lighted screen to the instructor.

**Station #4**

At station #4, titled “What’s Wrong with this Box?”, the students were required to look at powerless system tower, with the cover taken off. They were obligated to look over the entire system to find which components were missing or
unattached. The mouse trackball was removed, the mouse was unplugged from the system tower, one of the RAM memory pieces was removed, the monitor was unplugged from system tower, the power button was removed and the sound cord was unplugged from sound card. Teams responded with the following responses:

Team #1: "The sound cable is not plugged in. The ram is missing. The trackball for the mouse isn’t in. Plug in [the] mouse, keyboard and monitor. The power cable is not plugged in.

Team #2: "The ram is missing (1). The wire is not plugged in. The p5 (the internal power cord) wire is not plugged in. The [monitor] is not plugged into the power tower. The mouse is not plugged in. The trackball is missing. The power button is not there. The power cord.”

Team #3: "Sound cable. More ram. Trackball. Plug in mouse and keyboard and monitor and power cable plug in.”

Students were also asked if the computer was turned on, how the system would be affected. Team #2 did not respond. Other teams wrote the following responses:

Team #1: "You could not do anything or hear anything."

Team #3: "You could [not do] anything or [hear] anything.”

All three teams solved all the problems without guidance or clarification from the instructor. All teams successfully reassembled the computer by asking the instructor for each part missing. The students physically installed the missing RAM
and plug in the sound cord to the sound card, as well as attach all missing peripheral devices.

Station #5

At station #5, titled “EXAMPLE BOX”, students were just provided with an example computer set-up, in case they wished to use it for an example. Team #1 was the only team to visit this station to look over the example.

Station #6

At station #6, titled “Laptop Trauma”, students were required to perform two tasks. First, students needed to find a missing file titled “Lost Dog”, by using the search function within the Windows Operating System. The file was taken off the Recent Documents menu to ensure the students were using the search function. Teams wrote the following responses:

Team #1: “It is under Microsoft Word.”

Team #2: “Yes we found it. We went to search and pushed files and folders then we typed in lost dog.”

Team #3: “It was in Microsoft Word.”

The second part of station #6 required students to change the background picture on the desktop. Students needed to use the properties menu by right clicking on the desktop and selecting properties. Within the Display Properties, students selected a different background. The instructor verified successful completion by
noticing the changed background when notified of their conclusion. Teams wrote
the following responses:

Team #1: “You right click anywhere then you click properties. Then you go to
desktop and change the background.”

Team #2: “Yes. We right clicked then we went to properties. Then we clicked on
desktop and changed it.”

Team #3: “Yes. I went under desktop and found it.”

All three teams found the missing file and change the desktop background
without guidance from the instructor. All teams used the search function within the
Windows Operating System to find the missing file. All teams changed the
background by using the Display Properties menu.

Station #7

At station #7, titled “Trouble with Laptop Printing”, students were asked if
they could print from a laptop by simply plugging the printer into the laptop. There
was no printer software installed on the desktop, so the laptop would not have been
able to print from the printer. Teams wrote the following responses:

Team #1: “No, because you have to install it.”

Team #2: “No because after you hooked it up to the laptop you need to install it.”

Team #3: Students visited this station and successfully solved the problem, but did
not respond.
All three teams solved all the problems correctly without guidance or clarification from the instructor. The students all solved this problem together due to time constraints. Two teams answered the question on their worksheet.

Out of all the problems students attempted during the final troubleshooting activity, students solved every problem successfully without aid from the instructor. Throughout the troubleshooting activity, students followed a conventional problem solving process. The teams identified the common computer problems, and wrote the problems out on their team worksheet. They then proceeded to devise a plan or strategy to fix the problem. Teams correctly fixed/solved the problems, by reattaching devices or installing components. They were able to look back and verify their answers by accomplishing the task and receive feedback from the fixed machine. The computer was able to provide automatic feedback, as to whether the problem was solved. Students solved all common computer problems presented by the troubleshooting activity.

**Group Interview**

During the group interview, students solved a computer problem for a teacher within one day of the troubleshooting activity. The students were asked if they believed they could solve common computer problems. One student in the experimental group commented “we [solved a common computer problem] in like art. The printer wasn’t working; it was the same problem here. So we pressed the [power] button and [the printer] worked.” The students in the experimental group told the control group about the different computer troubleshooting stations they were able to fix (See Table 4.15).
Table 4.15
Excerpt From Group Interview – Transcribed Conversation

<table>
<thead>
<tr>
<th>RESEARCHER</th>
<th>Why don’t you guys try to tell them a little bit about what we did?</th>
</tr>
</thead>
<tbody>
<tr>
<td>#4 (experimental)</td>
<td>The first couple days we were just studying like what parts of the computers were the computers. We took apart the computers and um... and put them back together. Then like the last day, she took apart a computer and we had to put it back together with all the parts.</td>
</tr>
<tr>
<td>#6 (experimental)</td>
<td>We had to go to like stations and we had to figure out what it was and fix it.</td>
</tr>
<tr>
<td>RESEARCHER</td>
<td>You had to fix it. You had to figure out what it was first and then you had to fix it. So you had to identify the problem.</td>
</tr>
<tr>
<td>#2 (experimental)</td>
<td>We had to install and uninstall a program.</td>
</tr>
<tr>
<td>RESEARCHER</td>
<td>Did the people who went through the computer troubleshooting, did you guys have fun doing that?</td>
</tr>
<tr>
<td>All</td>
<td>Yeah.</td>
</tr>
<tr>
<td>RESEARCHER</td>
<td>Do you think that if your teacher had a problem with the computer that you could fix it?</td>
</tr>
<tr>
<td>All</td>
<td>Yeah.</td>
</tr>
<tr>
<td>RESEARCHER</td>
<td>So now you can help your teacher out in lab?</td>
</tr>
<tr>
<td>#4 (experimental)</td>
<td>We did it in like art. The printer wasn’t working; it was the same problem here. So we pressed the button and it worked.</td>
</tr>
<tr>
<td>RESEARCHER</td>
<td>Alright there you go. That’s fantastic guys! Thanks a lot. I really appreciate it.</td>
</tr>
</tbody>
</table>

Based on responses, the students felt comfortable in solving common computer problems. All students in the experimental group volunteered answers during group discussions, and were anxious to solve the problems, getting their hands
on the hardware and the computers. Students encountered all problems with enthusiasm, questions and logical progression of problem solving.

**Hypothesis 2**

Elementary students who participate in the computer troubleshooting curriculum will improve problem solving methods compared to elementary students in the control group.

**POPS – Profiles of Problem Solving Test**

Within the POPS test, there were five categories to assess the different elements of problem solving. According to the POPS teacher’s manual, the method used category contained activities related to problem solving strategies such as; working systematically, listing possibilities, finding and using patterns and generalizing. The control group table (Table 4.16) shows the difference between pre and post scores (See Figure 4.1). The experimental group table (Table 4.17) shows the improvement between pre and post scores (See Figure 4.2).

**Table 4.16**

Control Group Methods Used Section

<table>
<thead>
<tr>
<th>Student</th>
<th>Methods Used Pre-Test Score</th>
<th>Methods Used Post-Test Score</th>
<th>Methods Used Score Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>#3</td>
<td>7</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>#5</td>
<td>6</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>#7</td>
<td>4</td>
<td>3</td>
<td>-1</td>
</tr>
<tr>
<td>#9</td>
<td>8</td>
<td>7</td>
<td>-1</td>
</tr>
<tr>
<td>#11</td>
<td>7</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>6</td>
<td>5.83333333</td>
<td>-0.16667</td>
</tr>
</tbody>
</table>
Figure 4.1

Control Group Methods Used Section Graphed

Table 4.17

Experimental Group Methods Used Section

<table>
<thead>
<tr>
<th>Student</th>
<th>Methods Used Pre-Test Score</th>
<th>Methods Used Post-Test Score</th>
<th>Methods Used Score Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>#2</td>
<td>8</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>#4</td>
<td>4</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>#6</td>
<td>6</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>#8</td>
<td>5</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>#10</td>
<td>4</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>#12</td>
<td>3</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>5</td>
<td>7.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>
Figure 4.2
Experimental Group Methods Used Section Graphed

![Experimental Group Methods Used Section of POPS](image)

Only one student, student #3, in the control group improved in the methods used category. All other control group students either remained constant or decreased their score. The experimental students all improved their score in the methods used category by one or more points. On average, students in the experimental group improved 2.5 points in the methods used category between the pre- and post-tests. Students in the control group, on average, received .17 less points on the post-test, as compared to the pre-test.

**Hands-On Problem Solving Test**

To evaluate the methods students used, the hands-on problem solving activity was videotaped and assessed at a later time. The number of attempts for each problem during the pre-tests and the post-tests were analyzed, as well as the time needed to successfully complete the problem. Documentation of how the students attempted to solve the problem was also recorded from the videotape.
Figure 4.3
Comparing Differences of Groups with Number of Attempts in the Hands-On Pre-Test versus Post-Test

The control group on average (See Figure 4.3) showed a 49% decrease in number of attempts from the easy problem pre-test to the easy problem post-test. The control group on average also decreased in number of attempts by 55% from the difficult problem pre-test to the difficult problem post-test. The experimental group
on average increased the number of attempts by 13% on the easy problem pre-test to the easy problem post-test. The experimental group on average also increased in number of attempts on the difficult problem from the pre-test to the post-test by 23%. Therefore, the experimental group, on average, increased the number of attempts, while the control group, on average, decreased in the number of attempts.

All students solved the easy problem in less than the specified five-minute time period; therefore time comparisons can be made between groups (See Table 4.18).

Figure 4.4

Time Results from the Easy Problem in the Hands-on Pre- and Post-Test

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-Test Average Time</th>
<th>Post-Test Average Time</th>
<th>Difference in Time Between Pre-Test and Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1.38</td>
<td>1.0</td>
<td>0.38</td>
</tr>
<tr>
<td>Experimental</td>
<td>2.54</td>
<td>2.21</td>
<td>0.33</td>
</tr>
</tbody>
</table>
The difference between the control group's average improvement in time and the experimental group's average improvement in time was 0.042 minutes, amounting to 2.8 seconds. Due to the small numbers, the difference is not significant.

The difficult problem was much more complicated and many students were unable to solve the problem. The following table shows students who completed the difficult problem during either the pre-test, post-test or both as indicated below (See Table 4.19).

Table 4.19

Control Students’ Pre-Test and Post-Test Ability to Solve the Difficult Problem in the Hands-On Problem Solving Test

<table>
<thead>
<tr>
<th>Student</th>
<th>Group</th>
<th>Pre-Test Solution</th>
<th>Post-Test Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>Control</td>
<td>Not Solved</td>
<td>Solved Correctly</td>
</tr>
<tr>
<td>#3</td>
<td>Control</td>
<td>Not Solved</td>
<td>Solved Correctly</td>
</tr>
<tr>
<td>#5</td>
<td>Control</td>
<td>Not Solved</td>
<td>Not Solved</td>
</tr>
<tr>
<td>#7</td>
<td>Control</td>
<td>Solved Incorrectly</td>
<td>Solved Incorrectly</td>
</tr>
<tr>
<td>#9</td>
<td>Control</td>
<td>Solved Correctly</td>
<td>Not Solved</td>
</tr>
<tr>
<td>#11</td>
<td>Control</td>
<td>Not Solved</td>
<td>Not Solved</td>
</tr>
<tr>
<td>Total Control</td>
<td>Control</td>
<td>4 Not Solved</td>
<td>3 Not Solved</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 Solved Incorrectly</td>
<td>1 Solved Incorrectly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 Solved Correctly</td>
<td>2 Solved Correctly</td>
</tr>
</tbody>
</table>

Table 4.20

Experimental Students’ Pre-Test and Post-Test Ability to Solve the Difficult Problem in the Hands-On Problem Solving Test

<table>
<thead>
<tr>
<th>Student</th>
<th>Group</th>
<th>Pre-Test Solution</th>
<th>Post-Test Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>#2</td>
<td>Experimental</td>
<td>Not Solved</td>
<td>Not Solved</td>
</tr>
<tr>
<td>#4</td>
<td>Experimental</td>
<td>Solved Correctly</td>
<td>Solved Correctly</td>
</tr>
<tr>
<td>#6</td>
<td>Experimental</td>
<td>Not Solved</td>
<td>Solved Correctly</td>
</tr>
<tr>
<td>#8</td>
<td>Experimental</td>
<td>Not Solved</td>
<td>Solved Correctly</td>
</tr>
<tr>
<td>#10</td>
<td>Experimental</td>
<td>Solved Correctly</td>
<td>Not Solved</td>
</tr>
<tr>
<td>#12</td>
<td>Experimental</td>
<td>Not Solved</td>
<td>Solved Correctly</td>
</tr>
<tr>
<td>Total Experimental</td>
<td>Experimental</td>
<td>4 Not Solved</td>
<td>2 Not Solved</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 Solved Correctly</td>
<td>4 Solved Correctly</td>
</tr>
</tbody>
</table>
Figure 4.5
Comparing the Number of Students in Each Group not Able to Solve Correctly or Solve Incorrectly the Difficult Problem in the Hands-On Problem Solving Test

Figure 4.6
Comparing the Number of Students in Each Group Able to Correctly Solve the Difficult Problem in the Hands-On Problem Solving Test

Four students in the experimental group solved the difficult problem correctly during the post-test, whereas only two students in the control group solved the
difficult problem during the post-test. The results are not significant because two students who solved the problem correctly during the pre-test, were unable to solve the problem during the post-test. Each group contained one student who solved the problem correctly during the pre-test, but not during the post-test. The control group also contained one student categorized as solving the problem incorrectly.

**Hypothesis 3**

The most difficult procedure in problem solving for elementary students is to understand what the question is looking for.

**POPS – Profiles of Problem Solving Test**

The most difficult part of problem solving was analyzed through a review of literature and articles. Data was also collected through the Profiles of Problem Solving test and the surveys/interviews. The standardized problem solving test, POPS, divided the evaluation into five separate categories; Correctness of Answer, Methods Used, Accuracy, Extracting Information and Quality of Explanation. Each category was present in multiple questions and graded separately for each student. Every category was divided into three possible levels of achievement; beginning, developing and advanced. Each student was graded on the pre-test and post-test, using the three possible levels (See Table 4.21)
Table 4.21
Each Student’s Pre-Test Score on the POPS test Graded on Beginning, Developing or Advanced Levels of Achievement

<table>
<thead>
<tr>
<th>Student</th>
<th>Correctness of Answer</th>
<th>Method Used</th>
<th>Accuracy</th>
<th>Extracting Information</th>
<th>Quality of Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>B</td>
<td>D</td>
<td>B</td>
<td>B</td>
<td>D</td>
</tr>
<tr>
<td>#2</td>
<td>D</td>
<td>D</td>
<td>A</td>
<td>D</td>
<td>A</td>
</tr>
<tr>
<td>#3</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>A</td>
</tr>
<tr>
<td>#4</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>B</td>
<td>D</td>
</tr>
<tr>
<td>#5</td>
<td>D</td>
<td>D</td>
<td>A</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>#6</td>
<td>D</td>
<td>D</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>#7</td>
<td>B</td>
<td>D</td>
<td>B</td>
<td>B</td>
<td>D</td>
</tr>
<tr>
<td>#8</td>
<td>B</td>
<td>D</td>
<td>A</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>#9</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>#10</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>#11</td>
<td>D</td>
<td>D</td>
<td>A</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>#12</td>
<td>D</td>
<td>B</td>
<td>B</td>
<td>D</td>
<td>B</td>
</tr>
</tbody>
</table>

Total: B: 3 B: 1 B: 3 B: 3 B: 1
    D: 9 D: 11 D: 4 D: 8 D: 8
    A: 0 A: 0 A: 5 A: 1 A: 3

The most difficult categories for the students were, in order of difficulty; correctness of answer, extracting information and methods used. In these categories, there were more students who were in the beginning or developing stages.

Survey/Group Interview

During the survey/group interview, students were asked, “What is the hardest part about solving a problem?” Written responses and verbally expressed opinions
were both recorded and organized (Table 4.22) showing the different difficulties articulated by students. Students produced answers such as; identifying important information, understanding what the question is looking for, what to do with the information, looking back, not enough information and the type of strategy or plan to use.

Table 4.22
Student Responses to the Most Difficult Problem Solving Process

<table>
<thead>
<tr>
<th>Answer</th>
<th>Identifying important information</th>
<th>Understanding the question</th>
<th>Looking back</th>
<th>Lack of information</th>
<th>Method or strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency of students’ answers.</td>
<td>3</td>
<td>8</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

The researcher organized the students’ responses into separate categories to simplify the presentation of the data. Behind each title were key responses or key words used to define the category. Behind identifying important information, key phrases such as, “I don’t know what to do with the given information”, “what information is needed to solve the problem”, and “finding all the information” defined the category. Behind understanding the question, key phrases such as, “don’t understand it”, “don’t know what the question is asking you to do”, and “what the problem is looking for” defined the category. Behind looking back, key phrases such as, “knowing if your done” and “finding out the answer” defined the category. Behind lack of information, key phrases such as “not enough information” defined the category. Behind method or strategy, key phrases such as, “making a plan”, “how to” and “what type of strategy defined the category.
Based on the surveys and group interviews, most students found understanding the question the most difficult part of problem solving.

**Hypothesis 4**

Learning to troubleshooting computer problems will increase mathematical problem solving ability.

**IOWA Test**

Students in the experimental group and the control group both were pre-tested and post-tested using the IOWA Basic Skills math problem solving and data interpretation 26-item section of the IOWA test. The students were given the identical test for the pre-assessment and post-assessment.

**Figure 4.7**

![IOWA Scores Compared Between Mean Group Scores on the Pre-Test versus the Post-Test](image)

<table>
<thead>
<tr>
<th></th>
<th>Pre: IOWA</th>
<th>Post: IOWA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Control</td>
<td>19.83</td>
<td>22.17</td>
</tr>
<tr>
<td>Average Experimental</td>
<td>20.3</td>
<td>22</td>
</tr>
</tbody>
</table>

The mean scores of both groups produced similar results. While students in the control group improved 2.3 points, the experimental group improved 2.3 points...
from the pre-test to the post-test. The results provided identical and therefore showed no evidence of improvement in math problem solving skills resulting from the computer troubleshooting training sessions.

**Group Interview**

During the group interview, students made interesting comparisons between computer troubleshooting and problem solving, some related directly to mathematics. Students made references to the requirement to "figure out what the problem is" and "think[ing] of the solution of the problem." In mathematics, story problems require students to figure out what the problem is and brainstorm what the solution could be (Poris, 2000). Another student stated that, "finding out [what’s] wrong with a computer is a lot like finding out what the solution is in a question." Another student wrote, "I think [computer troubleshooting] helped [my problem solving skills] by learning strategies like in math," directly showing the similarity between computer troubleshooting and math problem solving for one student.

**Hypothesis 5**

There will be no effect on problem solving ability when gender is taken into consideration.

The existence of the gender gap in computer usage has been shown through multiple studies; females lack positive educational experiences with computers (Burge, 2001). Students were separated by gender in multiple ways, and data was collected, separated and analyzed by gender. The POPS pre-tests and post-tests total
scores were compared, as well as all category pre-tests and post-tests. The hands-on tests were also analyzed based on gender.

POPS – Profiles of Problem Solving Test

Data analyzed from the POPS total score pre-test and post-test showed females improving from the pre-test with an average score of 26.5 points to the post-test with an average score of 32.5 points. The males did not improve and retained a constant average score of 24.3 points through the pre- and post-test.

Table 4.23
Mean of POPS Pre-Test vs. Post-Test Total Score Comparing Females vs. Males

<table>
<thead>
<tr>
<th>Gender</th>
<th>Pre-Test: Total Score</th>
<th>Post-Test: Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>26.5</td>
<td>32.5</td>
</tr>
<tr>
<td>M</td>
<td>24.3</td>
<td>24.3</td>
</tr>
</tbody>
</table>

Data analyzed from the POPS Methods Used section and the Extracting Information section showed an average female improvement from the pre-test to the post-test. On average, males also improved; however, the results were not as significant. The females increased their average score by 22% on the methods used section, and the males increased their average methods used score by 11%. The females increased their average score on the extracting information section by 20%, and the males increased their average extracting information score by 3%.
Gender differences were also exhibited within groups. The female control group improved 14% in their total POPS score, while the male control group decreased their total POPS score by 11%. The female experimental group improved their total POPS score by 22%, while the male experimental group improved their total POPS score by 12%. The difference is represented in figure 4.10.
Comparison of the Methods Used and Extracting Information Categories of the POPS Test Between Mean Gender Score

Figure 4.9

Difference Between Gender on the Methods Used Section of POPS Pre-Test versus Post-Test

Difference Between Gender on the Extracting Information Section of POPS Pre-Test versus Post-Test

Table 4.25

Gender Comparisons Divided by Group of Total POPS Score on the Pre- and Post-Tests

<table>
<thead>
<tr>
<th>Gender</th>
<th>Group</th>
<th>Total Score Pre-Test</th>
<th>Total Score Post-Test</th>
<th>Total Difference Pre-Test Post-Test</th>
<th>POPS Btw. and</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>Control</td>
<td>23.3</td>
<td>27.0</td>
<td>3.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>29.7</td>
<td>38.0</td>
<td>8.3</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>Control</td>
<td>27.7</td>
<td>24.7</td>
<td>-3.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>21.0</td>
<td>24.0</td>
<td>3.0</td>
<td></td>
</tr>
</tbody>
</table>
On average, the females increased their total POPS scores by 18% between the pre-test and the post-test, whereas the males were only able to increase their total POPS score by 0.5% on average. When gender was analyzed by groups, females in the experimental group improved on a larger scale than the females in the control group. Likewise, in the male gender, when separated by groups, males in the experimental group improved, whereas males in the control group decreased in their total POPS score.

The average score for the females was higher than the males in every category within the POPS test. Females outscored the males in number of points improved in all categories as well.
Figure 4.11

Difference Between POPS Pre-Assessment and Post-Assessment Score on the Correctness of Answer Category Separated by Gender

Figure 4.12

Difference Between POPS Pre-Assessment and Post-Assessment Score on the Accuracy Category Separated by Gender
Throughout the POPS test categories, females improved more than the males (See Figure 4.11, 4.12, 4.13). Within the experimental group, the female experimental subjects improved more than the male experimental subjects. The female experimental subjects improved in their total POPS score from the pre-test to the post-test by 22%, while the male experimental subjects only improved by 10%. Both genders in the experimental group outscored their peers in the control group, showing the training made an impact regardless of gender. However, females in the control group and the experimental group were both improved their total POPS score average, although the experimental group improved 8% more than the control group. Males in the control group decreased their total POPS score, while the males in the experimental group achieved improvements in their total POPS score. The males in
the experimental group improved 20% more than their male counterparts in the control group.

**Hands-on Problem Solving Test**

The hands-on problem solving test was designed to examine the difference of computer troubleshooting on with a hands-on problem solving test.

**Figure 4.14**

Experimental Males versus Control Males Time to Complete the Easy Problem in the Hands-On Pre-Test and Post-Test

Males in the experimental group improved their time at a greater interval than their counterparts in the control group. Although both groups improved in time, the control males improved an average of approximately six seconds between the pre-test and post-test. Whereas the experimental males improved an average of thirty seconds between their pre-test and post-test.
However, the females in the experimental group did not improve as much as the females in the control group. The control group improved almost thirty seconds, whereas the experimental females only improved twelve seconds. This shows that the comparison of time is inconclusive and with small numbers, such fluctuation of data shows the females in the experimental group received no additional growth in hands-on problem solving from the computer troubleshooting training.

Time was not the only measure of improvement in the hands-on problem solving test. The number of attempts was an additional measure of assessment used.
Figure 4.16
Difference in Number of Attempts Between the Easy Problem in the Hands-On Pre-Test and Post-Tests Separated by Groups and Gender

Figure 4.17
Difference in Number of Attempts Between the Difficult Problem in the Hands-On Pre-Test and Post-Tests Separated by Groups and Gender
All groups decreased in their attempts between the pre-test and the post-test, except the male experimental group. In both the easy problem and the difficult problem, the male students in the experimental group were the only students to increase their attempts in either problem. All other groups decreased their attempts or remained constant in their attempts during both problems.

Overall, the data resulting from the hands-on problem solving test shows the experimental males improving more than their male peers in the control group and the females in both groups. The male experimental group also used more attempts to solve the difficult problem than the males in the control group. Overall, the most improvement in time completion on the easy problem was shown by the female control group, improving by more than 30 seconds on average. The female groups also saw a large decrease in number of attempts through both problems. The hands-on problem solving test was not substantial evidence to prove the theory either way.

Using all forms of assessment, POPS produced the most constant and obvious results. The male results were much less stable than their female counterparts. However, using the POPS tests, gender was analyzed and resulted with two main findings. Females scored higher on the pre-tests and post-tests than the males, however, males in the experimental group improved on a greater interval than their female counterparts.

Hypothesis 6

Students rated as high problem solving ability by their teachers will improve their problem solving ability within the experimental group as opposed to the control group.
Students in the experimental group and control group were matched by how their teachers rated their problem solving ability. When students were divided into teacher-rated problem solving groups, the results presented a different angle on improvements. Overall, students in the low problem solving group showed little increase in scores, and in numerous cases, decreased their score in the post-assessment.

Students in the different teacher-rated problem solving ability levels were analyzed using data from the POPS test and the Hands-on problem solving test to observe whether there was any noticeable difference between groups.

POPS – Profiles of Problem Solving

The POPS test was the first form of assessment used to see whether there was any difference between the teacher-rated problem solving ability groups. The total POPS pre-test score and post-test score was analyzed, as well as each individual category of the POPS test.

The results were divided by the teacher-rated problem solving ability level and provided interesting results. The researcher found the low problem solving ability group often decreased their scores. The two students rated as low problem solvers both rushed through all post-assessments and could be a possibility for the decrease. In the figure above (Figure 4.18), the graph shows the average increase of the high and medium experimental group, which improves at a greater interval than the average of the high and medium control group. The experimental group also started at a lower average score than the control group.
Figure 4.18
POPS Total Score Pre-Test and Post-Test Divided by Teacher Rated Problem Solving Ability and Groups

Figure 4.19
POPS Total Score Pre-Test and Post-Test High Teacher Rated Problem Solving Ability Separated by Groups
By analyzing group by group, the experimental group showed more results than the control group. The high problem solving ability control group increase at a very minimal level. The experimental high problem solving ability group increased at a much more dramatic rate.

Figure 4.20
POPS Total Score Pre-Test and Post-Test Medium Teacher Rated Problem Solving Ability Separated by Groups

The difference between the control and experimental medium problem solving ability subjects was not as extreme as the high problem solving ability groups. However, the experimental medium problem solving subject improved by nine points, or 30%, while the control subject improved by six points, or only 18%.
The low problem solving ability group results also presented better results in the experimental subject as opposed to the control subject. The low problem solving experimental subject decreased from a total pre-test score of 18 to a total post-test score of 17, while the control student’s score decreased from a 17 to a total post-test score of 11. Therefore, the experimental student did not produce as large of a drop as the control student in the low teacher rated problem solving ability group.

Students were separated into different problem solving ability groups for comparison purposes, to create equality among the sample groups. However, when analyzed data showed that the high and medium experimental group improved over
the high and medium experimental group. The low experimental group also produced more improvements on scores than the low control subject; however, since the data was collected from only 2 students, the results are unreliable.

**Hands-on Problem Solving Test**

When separated by problem solving ability level, the data results in the hands-on problem solving test remained similar to the overall results of the study. Students in all groups improved their time to complete the easy problem at nearly the exact same rate (See Figure 4.22).

**Figure 4.22**

Time Completion Compared by Problem Solving Ability for the Easy Problem in the Hands-On Problem Solving Pre-Test versus Post-Test
Table 4.26

Time Completion Compared by Problem Solving Ability for the Easy Problem in the Hands-On Problem Solving Pre-Test versus Post-Test

<table>
<thead>
<tr>
<th>Group</th>
<th>Average Time to Solve Pre-Test</th>
<th>Average Time to Solve Post-Test</th>
<th>Average Improvement Between Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Experimental Group</td>
<td>1.31</td>
<td>0.94</td>
<td>0.37</td>
</tr>
<tr>
<td>High Control Group</td>
<td>3.25</td>
<td>2.94</td>
<td>0.31</td>
</tr>
<tr>
<td>Medium Group</td>
<td>1.38</td>
<td>1.0</td>
<td>0.38</td>
</tr>
<tr>
<td>Low Group</td>
<td>1.25</td>
<td>0.88</td>
<td>0.38</td>
</tr>
</tbody>
</table>

All groups improved approximately 20 seconds, on average, therefore, time improvement was constant between all groups. However, the number of attempts students used to solve the problems varied greatly. Students in the high experimental group were the only subjects to increase their average number of attempts from the pre-test to the post-test, while still matching the time improvement rate of the other groups.

All other groups, besides the high experimental group, decreased their number of attempts while maintaining a similar time improvement of approximately 20 seconds. The high experimental group also maintained the same time improvement of approximately 20 seconds, while increasing their attempts. They averaged .75 more attempts in their post-test than in their pre-test. The high control group, medium group and low group all decreased in their number of attempts by an average of .5 attempts or more.
Figure 4.23

Number of Attempts on the Easy Problem in the Hands-on Pre-Test versus Post

Table 4.27

Percentage of Teacher-Rated Problem Solving Ability Grouped Students Able to Solve the Difficult Problem

<table>
<thead>
<tr>
<th>Teacher-Rated Problem Solving Ability Group</th>
<th>Difficult Problem Pre-Test</th>
<th>Difficult Problem Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Experimental</td>
<td>25%</td>
<td>50%</td>
</tr>
<tr>
<td>(4 students)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Control</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>(4 students)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>50%</td>
<td>100%</td>
</tr>
<tr>
<td>(2 students)</td>
<td>(100% Experimental)</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>0%</td>
<td>50%</td>
</tr>
<tr>
<td>(2 students)</td>
<td>(100% Experimental)</td>
<td></td>
</tr>
</tbody>
</table>
The students in all groups had trouble with the difficult problem in the hands-on problem solving test. The percentage of students within their teacher-rated problem solving ability groups who solved the difficult problem in the hands-on pre-test versus the post-test is shown above (See Table 4.27). There was no large improvement from any groups because the groups contained such small numbers. However, students in the medium and low problem solving groups had more success with solving the hands-on problem solving test. While only 38% of all the high problem solving ability students solved the difficult problem in less than five minutes during the post-test, 75% of the students in the low and medium problem solving ability groups solved the difficult problem. The low and medium problem solving ability groups could have benefited from the hands-on manipulation of solving the problem.

When separated by problem solving ability level, the data results remained similar to the overall results of the study. Overall, the students in the experimental groups outperformed the students in the control groups at all levels of problem solving ability. The experimental students rated high and medium showed more improvement than the experimental student in the low group.

**Hypothesis 7**

Computer troubleshooting will have an effect on elementary students' general problem solving skills.

The results from the numerous assessments show the experimental group improving more than the control group. Information was taken from the POPS test, the hands-on problem solving test and the group interview in order to evaluate
whether students in the experimental group achieved higher results in the post assessment than the students in the control group.

POPS – Profiles of Problem Solving Test

The POPS test, comprised of separate categories, presented information on the improvement of each group. The categories which were the most focused on in problem solving were the methods used section and extracting information. Although all categories are useful in problem solving, and the total score was analyzed, correlation was drawn between the two specified categories.

Figure 4.24

Difference in Total POPS Score Between the Pre-Test and Post-Test of Average Experimental Group versus Average Control Group

As seen in the information provided above (See Figure 4.28), the total POPS score, which analyzed the overall improvement of the students' ability to solve
problems, improved more in the experimental group, on average, as opposed to the control group’s average score. Both groups began relatively at the same level. The control group started out with an average pre-test score of 25.5, while the experimental group started out with an average pre-test score of 25.333. However, the improvements did not remain constant between the groups. The average experimental post-test score reached 31 points, improving an average of 5.67 points per student. The average control group post-test score reached 25.83 points, improving an average of .3 points per student. Therefore, the experimental group was able to improve an average of 5.3 points per student more than the control group between their POPS pre-test and post-test total score.

The individual categories were also analyzed to show whether the experimental students improved at a greater rate than the control students. The most important categories to the project were the methods used and extracting information. The accuracy, correctness of answer and quality of explanation were less important to the researcher and were not the focus of the project. The first category analyzed was the methods used category. The methods used category was analyzed earlier in hypothesis two, showing the large difference between the experimental group’s average improvement and the control group’s average improvement between pre-test and post-test (See Figure 4.1 and 4.2). The students in the experimental group improved an average of 2.5 points by increasing their average pre-test score of 5.0 points to an average post-test score of 7.5 points. The students in the control group actually dropped their average score 0.17 points, descending from an average pre-test score of 6.0 points to an average post-test score of 5.83 points. Therefore, the
experimental group showed an average improvement of approximately 33%, while the control group decreased an average of approximately 3%.

The extracting information category was another focal point of the project, because finding important information was indicated as one of the most difficult processes within solving a problem by the subjects. The extracting information results were not as evident as the methods used results, however, slight differences between groups were still present.

Figure 4.25
Comparing the Difference in POPS Extracting Information Section Pre-Test and Post-Test Between Groups

Students in the experimental group achieved an average pre-test score of 5.83 and an average post-test score of 6.67, improving an average of .84 points. Students
in the control group achieved an average pre-test score of 4.67 and an average post-test score of 5.33, improving an average of .66 points. Therefore, there was little difference between groups, but due to the small score, the average scores within the experimental group improved more than the control group.

The other categories were also compared between groups and the results are shown below (See Table 4.28)

Table 4.28

POPS Correctness of Answer, Accuracy and Quality of Explanation Categories Pre-Test and Post-Test Scores Compared Between Ability Groups

<table>
<thead>
<tr>
<th>Test Category</th>
<th>Group</th>
<th>Pre-Test Score</th>
<th>Post-Test Score</th>
<th>Difference in Pre-Test Score vs. Post-Test Score</th>
<th>Percentage Difference in Pre-Test Score vs. Post Test Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correctness of Answer</td>
<td>Control Group</td>
<td>4.83</td>
<td>6.33</td>
<td>1.50</td>
<td>24%</td>
</tr>
<tr>
<td></td>
<td>Experimental Group</td>
<td>5.67</td>
<td>6.50</td>
<td>0.83</td>
<td>13%</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Control Group</td>
<td>5.83</td>
<td>5.67</td>
<td>-0.16</td>
<td>-3%</td>
</tr>
<tr>
<td></td>
<td>Experimental Group</td>
<td>5.50</td>
<td>6.33</td>
<td>0.83</td>
<td>13%</td>
</tr>
<tr>
<td>Quality of Explanation</td>
<td>Control Group</td>
<td>4.17</td>
<td>2.67</td>
<td>-1.50</td>
<td>-35%</td>
</tr>
<tr>
<td></td>
<td>Experimental Group</td>
<td>3.33</td>
<td>4.00</td>
<td>0.67</td>
<td>17%</td>
</tr>
</tbody>
</table>

All three remaining categories were not as important to the project as the methods used and extracting information. The correctness of answer and accuracy categories were more mathematically centered than the other categories, and the
quality of explanation was based on the student's ability to explain their answer, and without specific training, it is difficult for students to improve in this category. In the accuracy and quality of explanation categories, experimental students improved their scores on the post-test, while students in the control group actually showed a decrease in scores on the post-test. While both group improved their scores on the correctness of answers category, students in the control group improved their scores by 24%, while the experimental group only improved 13%.

Overall, students in the experimental group showed greater improvement on the; total POPS problem solving test score, methods used score, extracting information score, accuracy score and quality of explanation score than the students in the control group. The results obtained from the POPS test show the experimental group was able to produce more improvements in general problem solving than the control group.

Hands-on Problem Solving Test

The hands-on problem solving test did not offer many results, showing similar improvements for both groups. The easy problem was solved by all students in both groups during the pre-test and post-test.

Both groups were almost identical in their improvement in time. As indicated in hypothesis two, students achieved similar results. Overall, the hands-on problem solving test provided very similar results in all aspects (See Table 4.31).
Table 4.29
Results from Easy Problem in Hands-on Problem Solving Test Comparing between Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of Attempts Pre-Test</th>
<th>Number of Attempts Post-Test</th>
<th>Time to Complete Pre-Test</th>
<th>Time to Complete Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group</td>
<td>2.67</td>
<td>1.3</td>
<td>1.38</td>
<td>2.5</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental Group</td>
<td>2.17</td>
<td>2.5</td>
<td>2.54</td>
<td>2.21</td>
</tr>
<tr>
<td>Group Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 4.26
Comparing Completion of the Easy Hands-on Problem Time Improvements Between Problem Solving Ability Levels

Although a small sample group was used, differences arose between the experimental group and control group pertaining to solving the difficult problem in the hands-on problem solving test. During the pre-test, only 33.3% of the experimental group solved the difficult problem, while 66.7% solved the difficult problem in the post-test. The control group produced less dramatic results of 16.7% of the group solving the difficult problem in the pre-test and 33.3% of the students solving the problem in the post-test. Therefore, more students in the experimental
group solved the problem, showing a great improvement in their score than the control group.

Figure 4.27
Comparing the Percentage of Students in the Control Group versus the Experimental Group Able to Solve the Difficult Problem in the Pre-Test and Post-Test

The number of attempts was the last section of the hand-on problem solving test to analyze and again the experimental group increased the number of attempts in the easy problem and the difficult problem from the pre-test to the post-test (See Table 4.32).

The experimental group increased from an average of 2.17 attempts in the pre-test to an average of 2.5 attempts in the post-test on the easy problem in the hands-on problem solving test. The control group decreased from an average of 2.67 attempts in the pre-test to an average of 1.33 attempts in the post-test on the easy problem in the hands-on problem solving test.
Table 4.30

Average Number of Attempts in Control Group versus Experimental Group and Percentage of Each Group Able to Correctly Solve the Difficult Problem

<table>
<thead>
<tr>
<th>Group</th>
<th>Average Number of Attempts Pre-Test</th>
<th>Average Number of Attempts Post-Test</th>
<th>Percentage of Group to Correctly Solve during Pre-Test</th>
<th>Percentage of Group to Correctly Solve during Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>4.83</td>
<td>2.67</td>
<td>16.7%</td>
<td>33.3%</td>
</tr>
<tr>
<td>Experimental</td>
<td>2.17</td>
<td>2.83</td>
<td>33.3%</td>
<td>66.7%</td>
</tr>
</tbody>
</table>

The experimental group increased from an average of 2.17 attempts in the pre-test to an average of 2.83 attempts in the post-test on the difficult problem in the hands-on problem solving test while the control group decreased from an average of 4.83 attempts in the pre-test to an average of 2.67 attempts in the post-test on the difficult problem in the hands-on problem solving test.

Overall, the experimental group increased their attempts during the post-test, while decreasing the amount of time to complete the test comparable to the control. The control group used less attempts while decreasing the amount of time taken to complete the problem comparable to the experimental. The most dramatic results were shown in the percentage of students who completed the difficult problem during the post-test, as compared to the pre-test. A higher percentage of students in the experimental group solved the difficult problem during the post-test than the students in the control group.
The group interview was conducted after the training session, on the last day of post-testing. All students from the experimental group and control group participated in the group interview. The researcher first had the students write responses to the questions on a sheet of paper, and then verbally discussed each question as a group. One of the questions presented to the students during the group interview was “Do you think learning how to troubleshoot a computer helped you with your problem solving skills? Why or why not?” Students were first asked to respond to the question with a written reaction, and then they were asked to verbalize any additional answers as a group. All the students in the experimental group chose to respond in some detailed fashion and wrote the following responses:

Student #2 in the experimental group wrote: “Yes. Because you had to figure out what the problem is and you have to think of the solution of the problem.”

Student #4 in the experimental group wrote: “Yes Because you learned how to fix things [easier] when we did the computer.”

Student #6 in the experimental group wrote: “I think it helped by learning strategies like in math.”

Student #8 in the experimental group wrote: “Yes I think troubleshooting will make a difference because finding out [what’s] wrong with a computer is a lot like finding out what the solution is in a question.”
Student #8 in the experimental group wrote: “Yes I think troubleshooting will make a difference because finding out [what’s] wrong with a computer is a lot like finding out what the solution is in a question.”

Student #10 in the experimental group wrote: “yes,”

Student #12 in the experimental group wrote: “No not really because I was just learning [to] put [together] and take apart [a computer].”

Five out of six students in the experimental group felt the computer troubleshooting training made a difference in their problem solving ability. Students made references to “figure out” problems, “fix things” and “finding out” information, which are key elements and steps in the problem solving process. They also mentioned “finding out what the solution is” and one student even compared the troubleshooting activity to “learning strategies like in math.” The student, who believed the computer troubleshooting sessions had no effect on problem solving skills, was teacher-rated as a low problem solving abilities student, who may still be operating at the concrete level of understanding, not the abstract level.

Students were also encouraged to expand on their writing by verbally discussing the question. The excerpt from the transcribed conversation (Table 4.33) showed how students verbally responded to one of the questions in the written interview “Do you think learning how to troubleshoot a computer helped you with your problem solving skills? Why or why not?” The researcher began the question discussion by prompting the students with the question and asked their opinion.
Students believed that the computer troubleshooting sessions had an effect on their problem solving skills. They drew references to the similarities between problem solving and computer troubleshooting activities. Students made references to having to “figure out” problems and “finding out what the solution is” comparing the solving of computer problems to the solving of general problems. Overall, the students concluded similarities and concluded that the computer troubleshooting training had advantages for general problem solving.

Table 4.31

Excerpt from Group Interview – Transcribed Conversation

<table>
<thead>
<tr>
<th>Individual Speaking</th>
<th>Direct Quotes from Individual</th>
</tr>
</thead>
<tbody>
<tr>
<td>#7 (control)</td>
<td>No.</td>
</tr>
<tr>
<td>RESEARCHER</td>
<td>Why do you think that?</td>
</tr>
<tr>
<td>#7 (control)</td>
<td>Because you were just taking apart a computer it wouldn’t really help problem solving.</td>
</tr>
<tr>
<td>#4 (experimental)</td>
<td>I think yes because we actually learned like, cause you didn’t help us that much. You just kind of took apart the computer and we had to think of all the parts that were missing and stuff.</td>
</tr>
<tr>
<td>#8 (experimental)</td>
<td>I had to figure out what was wrong with the computer. And it was a lot like trying to figure out the problem.</td>
</tr>
<tr>
<td>#2 (experimental)</td>
<td>Yes because we had to figure out what the problem was.</td>
</tr>
<tr>
<td>#12 (experimental)</td>
<td>No not really because it was just taking apart the computer.</td>
</tr>
<tr>
<td>#6 (experimental)</td>
<td>I think that it would help with like strategies and stuff because</td>
</tr>
</tbody>
</table>
like we had to use different strategies.

<table>
<thead>
<tr>
<th>RESEARCHER</th>
<th>OK so different strategies that you had to use. Why don’t you guys try to tell them a little bit about what we did?</th>
</tr>
</thead>
<tbody>
<tr>
<td>#4 (experimental)</td>
<td>The first couple days we were just studying like what parts of the computers were the computers. We took apart the computers and um… and put them back together. Then like the last day, she took apart a computer and we had to put it back together with all the parts.</td>
</tr>
<tr>
<td>#6 (experimental)</td>
<td>We had to go to like stations and we had to figure out what it was and fix it.</td>
</tr>
<tr>
<td>RESEARCHER</td>
<td>You had to fix it. You had to figure out what it was first and then you had to fix it. So you had to identify the problem.</td>
</tr>
<tr>
<td>#2 (experimental)</td>
<td>We had to install and uninstall a program.</td>
</tr>
<tr>
<td>RESEARCHER</td>
<td>Did the people who went through the computer troubleshooting, did you guys have fun doing that?</td>
</tr>
<tr>
<td>All</td>
<td>Yeah.</td>
</tr>
<tr>
<td>All</td>
<td>Do you think that if your teacher had a problem with the computer that you could fix it?</td>
</tr>
<tr>
<td>All</td>
<td>Yeah.</td>
</tr>
<tr>
<td>RESEARCHER</td>
<td>So now you can help your teacher out in lab?</td>
</tr>
<tr>
<td>#4 (experimental)</td>
<td>We did it in like art. The printer wasn’t working; it was the same problem here. So we pressed the button and it worked.</td>
</tr>
</tbody>
</table>
| RESEARCHER | Alright there you go. That’s fantastic guys! Thanks a lot. I
really appreciate it.
CHAPTER V

CONCLUSIONS AND DISCUSSION

Introduction

Computer troubleshooting has the possibility of enhancing problem solving learning experiences within the elementary curriculum. Computer troubleshooting training can also prepare students to assist in computer labs. The similar processes in computer troubleshooting and problem solving involve; identifying the problem, devising a solution and fixing the problem successfully. The researcher believes there is a strong relationship between developing computer troubleshooting skills and general problem solving skills.

The computer troubleshooting process also provides students with immediate feedback on the successful resolution of technical problems. The researcher believes the most difficult part of the problem solving process for elementary students is “understanding the question” or the problem. Computer troubleshooting assists in this development because the problem is straightforward, allowing students to easily identify the problem. Based on the evidence found in this study, elementary students are capable of learning how to troubleshoot common computer problems. Pending further research, the researcher concludes that learning how to troubleshoot a computer has the potential to improve problem solving ability in elementary students.
Summary of the Study

Summary of the Research Problem

Students currently receive insufficient problem solving learning opportunities (Coleman, et al, 2001; Jonassen, 2000). Problem solving skills are essential for a student’s future. Providing students with the skills to solve problems as opposed to merely supplying them with content knowledge enables the students to transfer the content knowledge to various situations requiring problem solving (Casey & Tucker, 1994). The research project explored the problem solving requirements necessary in computer repair and troubleshooting, and their effect on the academic achievement and academic problem solving of elementary students. Computer repair methods and troubleshooting techniques were used as models for teaching problem solving strategies. The study proposed to increase problem solving abilities and academic achievement among elementary students through the computer troubleshooting technology curriculum. With the findings from this research study, schools could incorporate the computer repair and troubleshooting training program into the curriculum. This could serve to enhance the problem solving learning experience and the teaching of technology skills.

Summary of the Methods

The research project was designed with a control/experimental pre/post test design. The whole study lasted two school weeks, including all testing periods. The purpose of the project was to establish whether computer troubleshooting had an
effect on problem solving skills. Each group included three boys and three girls, matched according to their problem solving ability levels as assessed by their teachers. Both groups received pre-assessment including two standardized tests, a hands-on problem solving test, and a survey collecting information from the students on problem solving skills, attitudes and math abilities. Following the two days of pre-testing, the experimental group attended computer troubleshooting training sessions, which were held for forty-five minutes in the morning before school over the course of five days. The control group received no training. Following the training, the students from the control and experimental groups were post-tested. The post-assessment included two standardized tests, the hands-on problem solving test and a group interview modeled from the survey. The pre-tests and post-tests were compared through statistical analysis, graphs and tables, as well as focusing on each individual student's growth in a case study approach.

Summary of the Findings

Hypothesis 1

The researcher used the findings from the troubleshooting activity as a means to assess whether the subjects could successfully troubleshoot common computer problems. The computer troubleshooting activity was an accurate simulation of common computer problems encountered in schools on a daily basis. The troubleshooting activity consisted of six interactive stations, each presenting a different common computer problem for the students to assess and solve. The
students worked in teams of two and solved all six problems, with the exception of one team who, due to time constraints, was only able to solve five of the six problems. Students recorded their answers on team worksheets, describing the problem and the measures they used to fix the problem. Through the computer troubleshooting activity, students demonstrated their computer troubleshooting ability by; reattaching power cords and peripheral devices, installing software programs, and physically installing ram and other hardware components. Overall, students identified the problem, devised a solution and fixed the problem.

The findings from the group interview were used to assess whether the subjects could successfully troubleshoot common computer problems. During the group interview, students in the experimental group explained the characteristics and requirements of the computer training sessions to the students in the control group. Students discussed taking apart computers, fixing the problems and installing programs. When asked if they would be able to assist their teacher with a computer problem, the students responded in unison, “Yeah.”

Findings from these two methods of assessment would suggest that students can learn to solve computer problems.

Hypothesis 2

The researcher used findings from the Methods Used section of the POPS test as a means to assess problem solving methods. Within the Methods Used section, most control students either demonstrated consistency or decreased in their score
between the pre-test and the post-test. Only one student in the control group improved their score by one point, and the average score for the group decreased 0.167 points between the pre-test and post-test. The students in the experimental group all improved by one point or more, creating an average improvement of 2.5 points between the pre-test and the post-test.

The second set of findings used to analyze whether students in the experimental group improved their problem solving methods was the hands-on problem solving test. The average number of attempts for the easy problem and the difficult problem was analyzed for each group. The experimental group used more attempts on average in the post-test than in the pre-test, while the control group achieved opposite results. The time necessary to complete the easy problem was also compared using average pre-test and post-test times of both groups. The improvement time for the control group and the experimental group were very similar, varying by only 2.8 seconds. The last set of findings in the hands-on problem solving test analyzed for the second hypothesis, were the number of students in each group able to solve the difficult problem. Four students in the experimental group solved the difficult problem correctly, while only two students in the control group were able to solve the problem correctly.

Findings from the Methods Used section of the POPS would suggest that students could improve their problems solving methods by learning to troubleshoot and repair computers. Findings from the hands-on problem solving test were found to be minimal and insignificant.
Hypothesis 3

The researcher assessed the most difficult procedure in problem solving for elementary students by using findings from the Profiles of Problem Solving test. Since the POPS test assessed students on different elements of problem solving, each category of the problem solving process could be separately analyzed by observing pre-test scores of the students. The most difficult procedures of problem solving, in order of difficulty were; correctness of answer, extracting information and methods used.

The second source of findings used to discover the most difficult problem solving procedure was the survey/group interview. When asked what the most difficult part of solving a problem out of five procedures, eight out of the twelve students responded with “understanding the question” was the most commonly mentioned procedure. Other procedures mentioned were; identifying important information, looking back, lack of information and the method/strategy to use.

Findings from the POPS test would suggest that students have the most difficulty with; correctness of answer, extracting information and methods used in the problem solving process. Findings from the group interview would suggest that “understanding the question” is the most difficult process in solving a problem.

Hypothesis 4

Information was collected from the IOWA Basic Skills math problem solving and data interpretation test and the group interview, in order to analyze whether
mathematical ability would be affected by the training sessions. The IOWA test results indicated that the average scores of the control group and the experimental group were identical and produced no significant results.

The group interview provided additional findings. Students made references to figuring out the problem and finding a solution to the problem. One student also made the comparison of learning strategies in computer troubleshooting to learning strategies in math.

Little evidence was found to support the improvement of math skills within either form of assessment.

**Hypothesis 5**

Gender differences were evaluated through the Profiles of Problem Solving test and the hands-on problem solving test. The POPS pre-test and post-test total scores were compared between genders, as well as each category of the POPS test. The females improved from a mean total score of 26.5 to 32.5, while the males retained a constant total mean score of 24.3 between the pre-test and the post-test. When separated by gender and group, the females in the experimental group improved by an average of 22% between the pre-test and the post-test, while the females in the control group improved by an average of 14%. The males in the experimental group improved by an average of 12%, while the males in the control group decreased their score by an average of 11%. Throughout the POPS categories,
the females outperformed the males in overall scores and in the improvement in scores between the pre-test and the post-test.

Additional results were collected from the hands-on problem solving test. The researcher compared the completion time for the easy problem from the pre-test to the post-test. The males in the experimental group improved their completion time of the easy problem by a greater percentage than the males in the control group. However, the females in the control group demonstrated greater improvement than the females in the experimental group in the completion time of the easy problem.

The findings for the number of attempts to solve each problem was also studied from the hands-on problem solving test to analyze the affects of gender on the results of the study. The males in the experimental group were the only group to have increased their average number of attempts in the post-test as compared to their pre-test average attempts.

The findings from the Profiles of Problem Solving test would suggest that there is little or no difference between gender-based results. Findings from the hands-on problem solving test presented conflicting data, the female control group and the male experimental group were able to improve in multiple areas. The findings were inconclusive.

Hypothesis 6

Students classified by teachers as having high, medium and low problem solving abilities were compared to evaluate if the variable was a significant factor.
The students in the high and medium experimental group improved their total POPS score by an average of eight points, while the high and medium control group improved their total POPS score by an average of three points. The low problem solving group decreased their average total POPS score from the pre-test to the post-test. When the ability groups were analyzed by treatment group, the experimental group’s improvement was more significant between the pre-test and post-test than the control group.

The hands-on problem solving test exhibited continuity across the ability problem solving groups. Each level of high, medium and low students demonstrated a similar improvement in time completion of the easy problem. High ability level students in the experimental group were the only students to increase their average number of attempts between the pre-test and the post-test. The number of students able to solve the difficult problem was also analyzed, but results were inconclusive due to small sample numbers.

When comparisons of the high, medium and low problem solving ability students were made, the findings from the POPS test would suggest that regardless of problem solving ability levels, students can improve their problems solving methods by learning to troubleshoot and repair computers. The findings also indicated that the high and medium ability level students in the experimental group were able to improve their scores more than the low ability student. Findings from the hands-on problem solving test were found to be minimal and insignificant.
Hypothesis 7

Information from the Profiles of Problem Solving test, the hands-on problem solving test and the survey/interview were all used to investigate the final hypothesis. The mean total POPS score was averaged for each group, comparing the pre-test total score to the post-test total score. The findings demonstrated a 25% increase for the experimental group, improving from an average score of 25.3 points to an average post-test score of 31 points. All individual sections of the POPS test favored the experimental group by demonstrating improvements of 20%, except the correctness of answer section, which only demonstrated a 13% increase.

The experimental and control group demonstrated the same improvement in time completion of the easy problem within the hands-on problem solving test. The experimental group increased their average number of attempts in both problems by 20% from the pre-test to the post-test, while the control group achieved opposite results, decreasing in the average number of attempts by 5%. 33% of the control group was able to solve the difficult problem, while 66% of the experimental group was able to solve the difficult problem.

The last collection of data analyzed to address the hypothesis was the final group interview. When students were asked if they felt computer troubleshooting could make an impact on problem solving skills, five out of the six students in the experimental group replied that computer troubleshooting did make a difference. References to figuring out problems and finding solutions were some of the additional comments given by students concerning the relationship between the two processes.
The findings from the Profiles of Problem Solving test would suggest that students could improve their problems solving skills by learning to troubleshoot and repair computers. Findings from the hands-on problem solving test were found to be minimal and insignificant. The findings from the group interview would suggest that students believed problems solving skills would improve from learning to troubleshoot and repair computers.

Conclusions

Hypothesis 1

Elementary students who participate in a computer troubleshooting curriculum will develop the ability to solve common computer problems by participating in computer troubleshooting trainings.

The computer training sessions included overviews of computer hardware components and repair. The training sessions included; the installation of programs, physical installation of components, and troubleshooting the operating system and other common computer problems. Once the students received all the training sessions, the instructor conducted a review discussion of different common computer problems; identifying why the problem exists and how to fix the problem. The computer troubleshooting activity was designed to emulate common computer problems, presenting a different problem at each of the six stations. The teams needed to study and solve the problem at each station, while recording their answers on the team worksheet. All three teams were able to solve all six problems, with the
exception of one team who, due to time constraints, was only able to attempt five of
the six stations. The elementary students exhibited their troubleshooting ability by
successfully reattaching power cords and peripheral devices, installing software
programs and physically installing internal hardware components. At every station
attempted, students identified the problem, devised a solution and fixed the problem
successfully without guidance or assistance from the instructor.

The group interview was also used to assess whether the elementary students
could successfully troubleshoot common computer problems. During the group
interview, students in the experimental group made reference to assisting a teacher by
troubleshooting a common computer problem. “We [solved a common computer
problem] in like art. The printer wasn’t working; it was the same problem [we had
encountered in the final computer troubleshooting activity].” The students in the
experimental group stated that they had gained the ability to take computers apart, fix
the problems and install programs.

Based on observations from the troubleshooting activity, students solved all
attempted common computer problems. The group interview confirmed that students
were comfortable with their new ability to solve computer problems, the researcher
believes elementary students can develop knowledge through computer
troubleshooting in order to solve common computer problems. When the students
were asked if they could assist their teacher with a computer problem in the future,
the students responded in unison, “Yeah.”
Hypothesis 2

Elementary students who participate in the computer troubleshooting curriculum will improve problem solving methods.

The Methods Used section of the POPS test and the hands-on problem solving test was used in order to assess whether the experimental students improved their problem solving methods. Most control students' scores either remained constant or decreased in their score between the pre-test and the post-test results, while all the experimental group students improved by one point or more, creating an average improvement of 2.5 points or 33%, between the pre-test and the post-test results. The instructor concludes that the experimental group demonstrated a significant improvement in the test results after the training sessions. The computer trainings sessions made a difference in the problem solving methods used by students in the experimental group.

Overall, the hands-on problem solving test was not a significant factor towards improving the problem solving methods. The number of attempts varied widely between the groups. The experimental group demonstrated an increase in the average number of attempts between the pre-tests and post-tests, while the control group showed a significant decrease in the average number of attempts. On average, the control group improved by completing the easy problem in less time as compared the experimental group, but the results were minimal and inconclusive. Four of the students in the experimental group solved the difficult problem in the post-test, while only two students in the control group solved the difficult problem in the post-test.
However, these results were also minimal, and due to the small number of student, the data is considered insignificant. The researcher believes the findings from the hands-on problem solving test were minimal and do not support the hypothesis.

**Hypothesis 3**

The most difficult procedure in problem solving for elementary students will be to understand what the question is looking for.

In the survey/group interview, students were asked to indicate the most difficult part of solving a problem. Eight out of the twelve students responded with the category “understanding the question”. The students classified under this category used key phrases such as; “I don’t understand [the question]”, “I don’t know what the question is asking you to do”, and “what the problem is looking for”. Based on these responses, students had difficulty determining what they needed to use the information for or exactly what the question was asking.

The POPS test evaluated each individual student on separate processes of problem solving. Each component of the problem solving process was analyzed by observing the pre-test scores of students. In the POPS test, the categories consisted of; correctness of answer, methods used, accuracy, extracting information and quality of explanation. The two categories most similar to “understanding the question” were methods used and extracting the information. Findings from the POPS test results indicated that the most difficult procedures for the students, in order of difficulty were the correctness of answer, extracting information and methods used.
The information obtained for this hypothesis established that students have the most difficulty with understanding and setting up the problem in order to solve it.

**Hypothesis 4**

Elementary students who participate in a computer troubleshooting curriculum will increase mathematical problem solving ability.

The information collected from the IOWA Basic Skills math problem solving and data interpretation section, as well as the group interview demonstrated no significant findings. However, the group interview provided additional information showing a possible relationship between mathematical reasoning and computer troubleshooting. Students made verbal and written references to figuring out the problem and finding a solution to the problem. One student also made the comparison that related strategies learned in computer troubleshooting to math by writing, “I think [computer troubleshooting] helped [my problem solving skills] by learning strategies like in math.” Based on group interview responses, students believe there is a correlation between mathematical problem solving and computer troubleshooting.

Based on findings presented in this hypothesis, there is no conclusive evidence that mathematical ability is affected by learning to troubleshoot and repair computers.
Hypothesis 5

Gender will not impact the problem solving ability of elementary students involved in a computer troubleshooting curriculum.

The existence of the gender gap in computer usage has been shown through multiple studies indicating that females lack positive educational experiences with computers (Burge, 2001). The major form of assessment used in analyzing possible gender differences was the Profiles of Problem Solving test. Females in the experimental group improved by 22% and the females in the control group only improved by 14%. Likewise the males in the experimental group improved by 12%, whereas males in the control group decreased by 11% in their total POPS score. It is difficult to conclude whether males or females were impacted more through the training sessions, although it is possible to conclude that the training session made an impact on the experimental group regardless of gender.

The hands-on problem solving test provided additional findings, but the results were difficult to evaluate. The males in the experimental improved more than the males in the control group regarding the completion time of the easy problem from the pre-test to the post-test. However, the females in the control group improved more than the females in the experimental group regarding the completion time of the easy problem from the pre-test to the post-test. The number of attempts to solve each problem was another source of data evaluated to analyze the effects of gender on the results of the study. The males in the experimental group were the only group to have increased their average number of attempts in the post-test as compared
to their pre-test average attempts. Due to the small sample and the nature of the test, the conclusions drawn from the hands-on problem solving test were inconclusive.

**Hypothesis 6**

Students who participate in a computer troubleshooting curriculum rated by teachers as having high problem solving ability will demonstrate greater improvements in problem solving ability.

The students rated as the high, medium and low problem solving ability levels by the teachers in the experimental group improved their total POPS score from the pre-test to the post-test more than the control group with similar ability levels. Therefore, the students in the experimental group were able to outperform every student with equivalent ability levels in the control group, demonstrating the positive educational impact of the training session. Based on the POPS data, the students rated with high and medium ability levels were able to achieve better results than their counterparts in the control group.

Both students rated as low ability problem solvers achieved lower total scores on their POPS post-test, than on the pre-test. However, the scores of the student in the experimental group identified as a low ability problem solver decreased less than the control student classified as a low ability problem solver. Interestingly enough, both students in the low problem solving group stated in the group interview that they believed the computer troubleshooting training sessions would have no effect on problem solving skills. Both students felt computer troubleshooting would have no
impact, stating that “because I was just learning [to] put [together] and take apart [a computer]”. The researcher hypothesizes that the students rated as low level problem solvers by their teachers may only have been able to function at a concrete level of understanding, unable to relate the abstract similarities of computer troubleshooting and problem solving.

In the hands-on problem solving test each group showed a similar improvement in the time completion of the easy problem from the pre-test to the post-test. More of the low and medium problem solving ability students were able to solve the difficult problem in the hands-on problem solving test. The researcher hypothesizes that students rated as having low and medium ability levels may have excelled on this portion due to the hands-on manipulation of the test. The hands-on problem solving test produced results, but the conclusions were questionable due to small sample numbers.

Based on the findings, students rated as having high, medium and low problem solving ability by their teachers improved their problem solving ability within the experimental group as opposed to the control group. However, evaluating which ability group improved their problem solving ability the most was difficult to conclude, due to the small sample.

**Hypothesis 7**

Elementary students who participate in a computer troubleshooting curriculum will demonstrate greater improvements in problem solving ability than students who did not participate in the program.
The mean total POPS score was averaged for each group. Comparing the pre-test total score to the post-test total score, the experimental group improved by 20%, while the control group only improved 3%. The students in the experimental group demonstrated a larger improvement in all sections of the POPS test, except the correctness of answer section. A paired samples t-test was run on the total POPS score data and a significance difference existed between the experimental group’s scores and the control group’s scores (See Appendix S). The students in the experimental group scored significantly higher than the control group.

In the hands-on problem solving test, the experimental group increased their average number of attempts during both problems from the pre-test to the post-test, while the control group decreased in their average number of attempts. The difficult problem was solved by 66% of the experimental group, while only 33% of the control group was able to solve the difficult problem. The findings from the hands-on problem solving test was inconclusive, because while the experimental group contained more students who solved the difficult problem, the numbers were too small to come to any firm conclusion.

The group interview provided information about whether students believed computer troubleshooting made an impact on their problem solving skills. Five of the six students in the experimental group believed that the computer troubleshooting training made a difference in their problem solving skills. Relationships were established between key elements of problem solving and computer troubleshooting by the students’ verbal and written responses.
Based on the evidence found in the study, the researcher believes computer troubleshooting training made a difference in the general problem solving skills of the experimental students. The author concludes that the computer troubleshooting sessions had a positive educational impact on elementary students' problem solving abilities.

Recommendations for Further Research

The researcher encountered many positive occurrences throughout the thesis process. The Human Subjects International Review Board (HSIRB) at Western Michigan University was extremely helpful in assisting in the research design process. The Board offered to meet with the researcher on several different occasions, constantly offering suggestions and educating the researcher on research design. Western Michigan University also loaned three surplus computers to the study, in order for the students to gain more hands-on experience with the internal hardware components.

The Dearborn Public School District was helpful in offering Haigh Elementary School as a setting for the research project. The building and resources were available to the researcher, as well as the supervision of an educator in the Dearborn Public Schools. Many students were interested in participating in the research study. The principal, as well as several parents stated that the study was a "wonderful educational opportunity for the children". The overall response to the study was overwhelming and positive.
The setting for the research study, located inside a classroom at Haigh Elementary School, was ideal and provided a chalkboard, desks, paper, pencils and additional working computers. Students had constant hands-on opportunities to work with the computers because of the additional computers from the University and the computers already located in the classroom.

The curriculum and the instructor were additional positive factors in the study. The curriculum was tailored to an elementary student level, incorporating excessive amounts of hands-on activities and simplified instruction. The instructor was A+ certified and a certified elementary educator, meeting the instructional needs of the students.

The researcher believes in the strong relationship between computer troubleshooting and problem solving skills. The computer troubleshooting training has multiple implications for the elementary curriculum, as well as for providing assistance to teachers in the computer labs. However, there were many limitations within the research project that need to be eliminated in future research.

The sample size of this study was created for convenience purposes. With any study, the more subjects that participate, the greater the ability to generalize and the more creditable the statistical tests are to determine the findings. Since the student sample in this study was small, only twelve students, the findings could not be generalized widely. The study did not allow for a completely random sample, and therefore, cannot be generalized to the entire fifth grade population in Dearborn. The location, demographics of the students, and other variables also limited the
implications of the research. By limiting the current study to only six students in each group, the researcher was able to provide ample amounts of hands-on, individualized instruction, as well as manage the large amounts of data collected from each student. The researcher also encountered difficulties gaining access to students, but was grateful to the Dearborn Public Schools for allowing the research project to take place. The time available to assemble and prepare the sample groups was limited based on the researcher’s need to complete the study before the end of the school year. Future studies should consider implementing a sample size of one hundred twenty subjects, more time to conduct the training, and more resources for the collection of the data.

The matching of students based on the disaggregates within each group was an additional challenge. The students were matched according to gender, attendance records and problem solving ability. Gender was not found to be a significant variable in the findings of the study. Attendance, used to exclude participants from the research project, was not a factor in the study. The researcher assigned students as high, medium or low problem solving ability status, based on ratings from their classroom teachers. The sample was taken from three separate fifth grade classrooms. Since there was no set definition of high, medium or low ability, teachers created the ratings based on their own classroom observations and assessments. Pre-testing students before assigning groups would alleviate the problem to control this variable. Through pre-testing, findings from the research could be focused more on directly comparing total scores, rather than comparing the
improvement in points for each form of assessment. The researcher would recommend in future studies that an appropriate problem solving test be used to categorize students.

Problem solving skills were difficult to monitor, assess and evaluate. The most common form of analysis requires subjects to verbally state every step they use during the problem solving process and the reasoning for those processes. However, due to time restraints and difficulty for elementary students to articulate their processes and reasoning, the researcher believed videotaping a hands-on problem solving test would be a more valid and effective measure of problem solving skills. The researcher was unable to locate many problem solving tests, and the testing methods retrieved from ETS, Educational Testing Services, were not endorsed.

The computer troubleshooting curriculum used in this study also offered additional limitations. Because the curriculum was designed and taught by the researcher, certain biases of the researcher were likely to be a part of the study. In future studies, care should be taken to eliminate all possible researcher biases. The researcher feels that curriculum revisions based on suggestions and videotaping of the instructional sessions could be used to improve the curriculum.

A reliable, cost efficient hands-on problem solving test was the most difficult test to identify. The researcher developed a hands-on problem solving assessment involving the use of tangrams. Hands-on intelligence quotient tests were available, but due to the cost of the tests and lack of funding, alternate tests were developed by
the researcher. The researcher would recommend that additional effort be made for finding a more appropriate hands-on problem solving test for future research.

The IOWA Basic Skills test and the Profiles of Problem Solving test were retrieved from the ETS, Educational Testing Services, but were not endorsed. The researcher attempted to select tests that had been used in multiple dissertations, thesis and research projects, to improve the credibility of the study. The researcher would recommend that additional effort be made to find more appropriate standardized tests for future research.

The researcher was also under time constraints such as; the end of the school year, HSIRB deadlines and University deadlines for the project. Future research projects should expand the time frame to four weeks. If students could be provided a longer training period and more tailored instruction, the students may be able to achieve scores on standardized tests indicating a greater increase in problem solving.

Final Conclusions

Based on the evidence presented in this study, elementary students are capable of learning how to and can troubleshoot common computer problems. The most difficult part of the problem solving process for elementary students is "understanding the question" or the problem. When students are provided with a concrete hands-on problem, it is much easier for the student to establish a problem and develop strategies and methods to solve the problem. The computer becomes a valuable tool for the student to manipulate, simplifying the establishment of the problem and the problem solving procedure. The computer troubleshooting process
also provides students with immediate feedback as to whether they successfully solved the problem. The researcher believes there is a definite relationship between computer troubleshooting skills and general problem solving skills. The similarities of identifying the problem, devising a solution and fixing the problem successfully exist in both computer troubleshooting and other forms of problem solving. The computer troubleshooting training has multiple implications for the elementary curriculum, as well as providing assistance to teachers in the computer labs. With further research, computer troubleshooting has the potential ability to enhance the problem solving learning experiences in elementary schools.
BIBLIOGRAPHY


Wonocott, Michael. (2001). *Technology Literacy*. ERIC Clearinghouse on Adult, Career, and Vocational Education, Columbus, OH.

Appendix A

Human Subjects Institutional Review Board
Date: May 7, 2003

To: Howard Poole, Principal Investigator
   Ann Ottenbreit, Student Investigator for thesis

From: Mary Lagerwey, Chair

Re: HSIRB Project Number 03-04-04

This letter will serve as confirmation that your research project entitled “Effects of Computer Troubleshooting on Elementary Students’ Problem Solving Skills” has been approved under the full category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you may only conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: April 16, 2004
Appendix B

Student Assent Form
You have been asked to participate in a study entitled “Computer Troubleshooting and Effects on Elementary Problem Solving.” The purpose of the study is to see if the training with the Computer Troubleshooting and Repair program will help you with your problem solving skills and math problem solving skills.

Before the training starts, you will be tested using 2 standardized tests, 1 hands-on problem solving activity and a survey to tell how you feel about problem solving. You will also be tested after the program using the 2 standardized tests again, the hands-on problem solving test and an interview, by Mrs. Ottenbreit, to see if you improved in problem solving. Even if you agree today to participate by signing this form, you can change my mind at any time when we begin training or at any time during the training. You are volunteers and you are free to stop participating whenever you want and there will be no penalties for quitting.

Your name will not be on any of the forms or videotapes. The researcher will use a code number instead. The researcher will keep a list of names and code numbers that will be destroyed once the researchers have recorded the important information. If you have any questions or concerns about this study, you may contact either Anne Ottenbreit at 313-516-6217 or Dr. Howard Poole at 269-387-6050 or Sharon Ottenbreit at 313-730-3130.
Appendix C

Parental Permission Slip (Letter A)
Dear Parents,

The fifth grade students at Haigh Elementary School have the opportunity to participate in a research project conducted by a graduate assistant in educational technology from Western Michigan University during the month of May. This research project will include 12 5th grade students who volunteer to be in the study. However, only six students will be selected for the experimental group, which are the students who will be assigned to receive the training, and 6 students will be selected to participate in the control group, which will not participate in the training sessions. It is important to have some students who are trained and some who are not trained so we can assess the value of the training. A selection process will be used to choose the six students to participate in the project if more than 12 students volunteer. The selection process will be performed by the researcher, based on the following criteria: gender, attendance records, and problem solving ability. The control group will be an important part of the project, measuring against the experimental group to see if the training program can make a difference.

The researcher believes the training sessions will have an affect on the students' problem solving skills and math ability. These children will learn about the different parts of a computer and their functions and to be taught to troubleshoot if the computer is not working. They will be using a hands-on approach and working with an actual computer. The children will be instructed by the Western Michigan University graduate assistant and supervised by Mrs. Ottenbreit. It will require that these students attend a two-week course, five days a week from May 19th through May 30th, 2003. The computer training will be done in Room 4, Mrs. Ottenbreit’s room, from 8:00 A.M. until 8:45 A.M. Prior to and at the end of the training sessions, these children will be tested to see if the computer training has improved their problem solving skills as opposed to those that did not receive the training. Your child must be able to attend all ten sessions.

All students who volunteer for the study will be provided with a Creative Computer Night, making their own animated/narrated story on CD. Each student will be able to keep the CD. This should be a wonderful opportunity and learning experience for your child!

The 12 students who participate in the study will be assessed on their problem solving skills and math problem solving skills. The pre- and post-tests will take about one hour and will be done in a relaxed and positive testing climate. The testing results will be kept confidential and the students' names will not be used in the research's report. The results
of the training sessions and the project will be shared with the classroom teachers, however, no individual student results will be released to the teacher.

If you have any questions, please contact Mrs. Ottenbreit at 730-3130. Please return the permission slip below by Friday, May 16th, 2003. Thank you.

Sincerely,
Mrs. Sharon Ottenbreit

-----------------------------------------------------------------------------------

Problem Solving Research Project
Western Michigan University

Student ____________________________

YES I give my child permission to participate in this research project. I realize that my child will need to participate in testing and attend all ten training sessions from 8:00 AM until 8:45 AM, Mondays through Fridays, beginning the week of May 19th through the week of May 30th, 2003 in Room 4 at Haigh Elementary School.

___ I do not want my child to participate in this project.

Parents Signature ____________________________ Date 5/13/03

___ My child has safety patrol duty during these two weeks. Please try to make arrangements so my child can participate.
Appendix D

Parental Consent Form (Letter B)
Dear Parent/Guardian,

Your child has been invited to participate in a research project entitled “Effects of Computer Troubleshooting and Repair on Elementary Problem Solving Skills.” The purpose of the study is to determine the usefulness of computer troubleshooting and repair curriculum in preparing elementary students in problem solving skill development. This project is being conducted to fulfill Anne Ottenbreit’s thesis requirement.

Your permission for your child to participate in this project means that your child will be administered the IOWA Basic Math Skills Test and the Profiles of Problem Solving Standardized Test. The testing will take place during May and will involve about one hour. Your child will also be administered hands-on problems solving test twice as a pre- and post-test. The process will be videotaped in order to document problem solving skills. All tests will be conducted in a positive testing environment by Sharon Ottenbreit. Your child will also be taken through computer training sessions, which will last 2 weeks starting on May 19th. Your child will be free at any time -- even during the test administration -- to choose not to participate. If your child refuses or quits, there will be no negative effect on his/her school programming. The test results will be used to establish a baseline data collection providing the researcher with information on current levels of problem solving. The results will help with subject selection for the control group and experimental group. Although there may be no immediate benefits to your child for participating, there may eventually be benefits to the school district and subsequently to students in technology education programs. The researcher believes the training sessions may have a positive effect on problem solving skills. If the results of the actual project are found to be useful, then current technology education program could be modified to include repair and troubleshooting within the curriculum.

All test data and information will remain confidential. That means that your child’s name will be omitted from all test forms and a code number will be attached. The principal investigator will keep a separate master list with the names of the children and the corresponding code numbers. If the researchers find that these two tests are useful for planning your child’s programming, they will share the results with your child’s teacher, unless specified otherwise. Once the data are collected and analyzed, the master list will be destroyed. All other forms will be retained for at least three years in a locked file in the principal investigator’s office. No names will be used if the results are published or reported at a professional meeting.

The only risks anticipated are minor discomforts typically experienced by children when they are being tested (e.g., boredom, mild stress owing to the testing situation). All of the usual methods employed during standardized testing to minimize discomforts will be employed in this study. The other possible risks are those involved in computer repair (e.g., minor scrapes, and in extreme rare cases, electrostatic shock). All computer safety methods will be exhibited by the instructors. More information can be provided if requested on the exact safety measure taken by
Appendix E

Additional Information Requested by Parents
Risks to Subjects

Potential risks to the subjects are as follows:

1. Subjects could miss academic learning time in the classroom in order to participate in brief testing.
2. Students could experience frustration or boredom during the testing and/or training.
3. Subjects could feel uncomfortable about videotaping in the classroom.
4. Students could experience minor scrapes due to the hands-on nature of the program.
5. Students, in extreme rare cases, could receive an electric static shock.

Protection of Subjects

Possible risks to subjects are extremely limited due to the extremely precautions safety procedures. Student risks could include slight boredom from the tests. Other risks could include minor scrapes from computer edges and in severe cases, slight electric static shocks. However, the instructor has carefully designed the curriculum to reflect safety precautions expressed in the A+ technician requirements. The instructor is a certified elementary educator and a certified computer technician, building her own computer, and is able to monitor safety of the small experimental group. There will also be an additional elementary school teacher to assist in safety features during the training sessions and testing sessions.

In order to minimize the potential risks listed above, the following precautionary measure will be taken:

1. The researcher will attempt to limit testing time, or utilize a period in the day when students would be conducting non-learning activities. The training will be taking place before school, so training will not use academic learning time in the classroom.
2. The subjects will be reminded that the test needs to be completed to the best of their ability. Teacher will reiterate: “This is not a grade, I just want to find out what you already know, so I don’t teach you the something you already know.” The teacher for signs of boredom or frustration will also monitor subjects during test taking procedures. Students experiencing these problematic feelings will be allowed to take a break and try again. If this does not succeed, students may stop taking the test. The instructor will monitor students experiencing boredom or frustration during the training procedures. The difficulty of the program will be adapted accordingly. The students are broken up into pairs and this is easily manageable, plus the grouping may keep otherwise bored/frustrated students engaged.
3. The videotape will be set up prior to taping so as not to disrupt the training. If the student continues to feel uncomfortable, the instructor will move the video camera to a hidden location.
4. Students will be instructed on the first day how to handle the computer equipment. Every time before they are allow to interact with the machine, they will be reminded of the metal parts and how to safely manipulate the equipment.
The instructor will model careful manipulation of the materials, to illustrate to the students how to correctly handle the equipment. Band-aids and first aid kits will be keep on hand at all times.

5. Students will be instructed on the first day how to handle the equipment. Students will remember to ground themselves, which requires touching a table or an object which is not electrostatic charged and to put the ESD strap on, which grounds them to a table, before working on the computer. There is no supposed risk if the computer is not plugged in. The instructor will remove all power cords prior to the beginning of the training and place them in a safe container in the room. When students reach the point of training to anticipate whether they can troubleshoot the hardware problems, the instructor will then place the power cord back into the computer, model the safety techniques, ensure the students complete the same procedure and then work together. In case of extreme rare circumstances, a cellular phone will be kept on person at all times, as well as student emergency slips, in case of emergency.

The instructor is a certified computer technician through CompTIA A+ certification training and testing. The A+ curriculum learning objectives included:

- This domain requires the knowledge of safety and preventive maintenance. With regard to safety, it includes the potential hazards to personnel and equipment when working with lasers, high voltage equipment, ESD, and items that require special disposal procedures that comply with environmental guidelines. With regard to preventive maintenance, this includes knowledge of preventive maintenance products, procedures, environmental hazards, and precautions when working on microcomputer systems.
- Identify the purpose of various types of preventive maintenance products and procedures and when to use and perform them: Liquid cleaning compounds; Types of materials to clean contacts and connections; Non-static vacuums (chassis, power supplies, fans).

Identify issues, procedures and devices for protection within the computing environment, including people, hardware and the surrounding workspace: UPS (Un-interruptible Power Supply) and suppressers; Determining the signs of power issues; Proper methods of storage of components for future use; Potential hazards and proper safety procedures relating Lasers High-voltage equipment; Power supply; CRT. Special disposal procedures that comply with environmental guidelines: Batteries; CRTs; Toner kits/cartridges; Chemical solvents and cans; MSDS (Material Safety Data Sheet). ESD (Electrostatic Discharge) precautions and procedures: What ESD can do, how it may be apparent, or hidden; Common ESD protection devices; Situations that could present a danger or hazard.

(http://www.comptia.org/certification/A/default.asp.)
Appendix F

Cover Sheets for Tests
Circle Test:

IOWA Math Skills
**Pre-Test / Post-Test**

Problem Solving Standardized Test
**Pre-Test / Post-Test**

Hands-On Problem Solving Test
**Pre-Test / Post-Test**

Survey

Interview
Appendix G

Survey
What do you think about problem solving?

ID Number: ____________________________

Date: ____________________________

Directions: Below are some statements about your own thinking about problem solving. There are no rights or wrong answers. Use the following scale and write the number which best describes how much the statement is like you. Please answer honestly and do not skip any statements.

Not me at all Very little like me A little like me Kind of like me A lot like me Describes me perfectly
1 2 3 4 5 6

_____ 1. Before trying to solve a problem I try to compare it to one that I have solved before.

_____ 2. Before trying to solve a problem I identify as many pieces of information that might be needed for problem solution.

_____ 3. I can figure out how to solve a problem without making a plan.

_____ 4. I have trouble in solving a problem when I do not know what information is important from what is not.

_____ 5. Before trying to solve a problem I say the information over again in my own words.

_____ 6. Before trying to solve a problem I think of a strategy that might lead to a problem solution.

_____ 7. When I am stuck on a problem I ask myself, “Did I look at all of the important information in the question?”

Questions 8, 9 and 10 will help me figure out how you solve problems. Answer them in your own words.

8. What are some of the ways you solve a problem? ____________________________
9. What is the hardest part about solving a problem? ____________________________

10. When you don’t know what the solution is, what can you do? __________________
Appendix H

Interview
**What do you think about problem solving?**

*The Interview*

ID Number: ____________________________________________________________

Date: _____________________________________________________________

**INTERVIEW FORMAT**

<table>
<thead>
<tr>
<th>Not me at all</th>
<th>Very little like me</th>
<th>A little like me</th>
<th>Kind of like me</th>
<th>A lot like me</th>
<th>Describes me perfectly</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

The interviewer will fill in this information for the student.

1. Before trying to solve a problem I try to compare it to one that I have solved before.

2. Before trying to solve a problem I identify as many pieces of information that might be needed for problem solution.

3. I can figure out how to solve a problem without making a plan.

4. I have trouble in solving a problem when I do not know what information is important from what is not.

5. Before trying to solve a problem I say the information over again in my own words.

6. Before trying to solve a problem I think of a strategy that might lead to a problem solution.

7. When I am stuck on a problem I ask myself, “Did I look at all of the important information in the question?”

8. What are some of the ways you solve a problem?

9. What is the hardest part about solving a problem?

10. When you don’t know what the solution is, what can you do?

11. Do you think that learning how to troubleshoot a computer helped you with your problem solving skills? Why or why not?
Appendix I

Code Sheet
**Code Sheet**

**Access Allowed to Dr. Howard Poole, Anne Ottenbreit and Sharon Ottenbreit**

Students will be placed into the slots as they turn in their permission slips to participate in the project. The control group will be the last six, and will be decided after the testing. The testing information will be kept in a separate database, assigning information to the student identification numbers only.

<table>
<thead>
<tr>
<th>Student Name</th>
<th>Student Identification Number</th>
<th>E=Experimental Group</th>
<th>C=Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>C</td>
<td></td>
</tr>
</tbody>
</table>
Appendix J

Observational Rubric of Hands-On Problem Solving Test
Observation of Hands-On Problem Solving Test
(Form ____)
Circle: Pre-Test / Post-Test
Student Code Number: ____________

**First Problem (Easy)**

<table>
<thead>
<tr>
<th>NUMBER OF ATTEMPTS</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15+</th>
</tr>
</thead>
<tbody>
<tr>
<td>How many times did the student clear the board and try a new approach?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AMOUNT OF TIME</th>
<th>0:15</th>
<th>0:30</th>
<th>0:45</th>
<th>1:00</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:15</td>
<td>1:30</td>
<td>1:45</td>
<td>2:00</td>
<td></td>
</tr>
<tr>
<td>2:15</td>
<td>2:30</td>
<td>2:45</td>
<td>3:00</td>
<td></td>
</tr>
<tr>
<td>3:15</td>
<td>3:30</td>
<td>3:45</td>
<td>4:00</td>
<td></td>
</tr>
<tr>
<td>4:15</td>
<td>4:30</td>
<td>4:45</td>
<td>5:00</td>
<td></td>
</tr>
</tbody>
</table>

Did not solve at all _____
Did not solve correctly _____
Solved correctly _____

| METHODS | |
|---------| |
| List some methods the student was using to solve the problem. | |
## Second Problem (Difficult)

### NUMBER OF ATTEMPTS

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15+</th>
</tr>
</thead>
</table>

How many times did the student clear the board and try a new approach?

### AMOUNT OF TIME

<table>
<thead>
<tr>
<th>0:15</th>
<th>0:30</th>
<th>0:45</th>
<th>1:00</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:15</td>
<td>1:30</td>
<td>1:45</td>
<td>2:00</td>
</tr>
<tr>
<td>2:15</td>
<td>2:30</td>
<td>2:45</td>
<td>3:00</td>
</tr>
<tr>
<td>3:15</td>
<td>3:30</td>
<td>3:45</td>
<td>4:00</td>
</tr>
<tr>
<td>4:15</td>
<td>4:30</td>
<td>4:45</td>
<td>5:00</td>
</tr>
</tbody>
</table>

How long did the student take to fully solve the problem?

(Measured in minutes)

Students receive 5 minutes for each problem.

- Did not solve at all _____
- Did not solve correctly _____
- Solved correctly _____

### METHODS

List some methods the student was using to solve the problem.
Appendix K

Group Interview and Survey Response
GROUP INTERVIEW: Transcribed Conversation

RESEARCHER (To the group): The first question is: Read So... if that’s kind of like you, go ahead and fill it out like it says on the top. Do you guys want to fill out the first seven yourself and then we’ll talk about the last few together
(To another student) You’re all done... I have one more thing for you.
(To the group) When you’re done, can you go ahead and flip it over so I know you’re all done?

Talk about bathroom...
Can you wait just a couple more minutes?

11 walks in.

RESEARCHER: You made it just in time.

2: Why did you come in now?

11: I forgot.

The noise made the talking between the students difficult.

RESEARCHER (to the second graders): Second graders, can you do me a big favor? Can you keep your voices down because we are trying to do a videotape back here? So can you do whatever work you are supposed to do, you’re supposed to be studying your spelling words? Thank you.

RESEARCHER (to the group): So turn it over now. Number 8 if you turn to the first page, the back of the first page. It’s right on the top line there. Go ahead and write down a few things. Then we’re going to share them as a group. Go ahead and flip it over when your done and then we’ll talk about it later. So what are some different ways that you guys try to solve problems?

4: I look for all of the things I need and then I try and figure out the problem
You guys can just put down your pens and stuff down. We’re just talking right now.

8: I try and find out what strategies to use.

RESEARCHER: Ok what kind of different strategies do you use

8: Like um whether to multiply, or add...

RESEARCHER: Ok so you’re trying to extract out all the information.

2: I try and find out all the information that I need and I sometimes...
9: Find out number sentences

RESEARCHER:

1: Reading

3: Reading

11: Um... I look at all the information and see what it is telling me to do

4: I look at the problem and see what information I need to solve the equation or to solve the information

6: Reading

RESEARCHER: Alright sounds good. Anybody else... What are some ways that you solve problems? Anything different?

9: Guess and check. Trial and error. I try to work the problem backwards

RESEARCHER: Alright, so you’ve got lots of different ways to solve problems. Alright. What about number 9? Read it. What do you think the hardest part is? Go ahead and write it down and then we’ll share.

RESEARCHER: Did you already finish this one?

2: (Shakes her head.)

RESEARCHER: Alright. So what do you guys think the hardest part about solving a problem is?

4: Maybe the problem doesn’t give enough information so you can solve it

5: Not being able to figure out what the problem is asking for and sometimes making a plan to figure out what strategies to use

?: Not enough information figuring out what it’s asking for. Figuring out what it’s asking you to do.

RESEARCHER: Alright so just figuring out what kind of strategy you are going to use

11: Not enough information.

RESEARCHER: Not enough information. Is it usually that there’s just not enough information, or it’s hard to figure out what you’re using the information for

11: Hard to figure out

RESEARCHER: What the heck they what you to do right?

2: What they want you to find out of the information?

RESEARCHER: Ok so sometimes the question at the end just doesn’t make sense
8: You don’t know what the questions is asking you to do?
RESEARCHER: So we’ve all got pretty much the same. It’s just the questions are hard
to figure out exactly what they want us to do. After that we can do it; no problem right?
We make a number sentence or draw a picture. Then we can solve it. Go ahead and go
to number 10.
11: I have 2 8 and 9’s, I don’t have a number 10.
RESEARCHER: Here you can have mine.
RESEARCHER: So when you don’t know what the solution is, what can you do?
Are you all done? So when you don’t know what the solution is, what can you do?
5: Make a plan to figure out
RESEARCHER: OK. What kind of plan would you make?
Then multiply or…?
RESEARCHER: Ok. So just try and take as much information as you can.
You can make
4: Read.
Sounds good
9: Read the problem over and over again.
RESEARCHER: OK
3: Ask for help
2: You can guess and check.
RESEARCHER: How about you 7?
RESEARCHER: The last one is number 11. Read. This is just for the kids who did the
actual troubleshooting, the actual computer training, but if you want to tell me what you
think. If you think it would make a difference, If you want to. You don’t have to.
9: Can we put a line through it.
RESEARCHER: Yeah. You can just put a line through it.
7: No.
RESEARCHER: Why do you think that?
7: Because you were just taking apart a computer it wouldn’t really help problem
solving.
4: I think yes because we actually learned like, cause you didn’t help us that much. You just kind of took apart the computer and we had to think of all the parts that were missing and stuff.
8: I had to figure out what was wrong with the computer. And it was a lot like trying to figure out the problem.
2: Yes because we had to figure out what the problem was. reading
12: No not really because it was just taking apart the computer.
6: I think that it would help with like strategies and stuff because like we had to use different strategies. read

RESEARCHER: OK so different strategies that you had to use. Why don’t you guys try to tell them a little bit about what we did?
4: the first couple days we were just studying like what parts of the computers were the computers. We took apart the computers and um… and put them back together. Then like the last day, she took apart a computer and we had to put it back together with all the parts.
6: We had to go to like stations and we had to figure out what it was and fix it.

RESEARCHER: You had to fix it. You had to figure out what it was first and then you had to fix it. SO you had to identify the problem.
2: We had to install and uninstall a program.

RESEARCHER: Did the people who went through the computer troubleshooting, did you guys have fun doing that?
All: Yeah.

RESEARCHER: Do you think that if your teacher had a problem with the computer that you could fix it?
All: Yeah.

RESEARCHER: So now you can help your teacher out in lab?
4: We did it in like art. The printer wasn’t working; it was the same problem here. So we pressed the button and it worked.

RESEARCHER: Alright there you go. That’s fantastic guys! Thanks a lot. I really appreciate it.
Appendix L

Survey and Interview Rubric
<table>
<thead>
<tr>
<th>Answer</th>
<th>Identifying important information</th>
<th>Understanding the question</th>
<th>Looking back</th>
<th>Lack of information</th>
<th>Method or strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency of students' answers.</td>
<td>3</td>
<td>8</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
Appendix M

IOWA Test Review
Test Name: Iowa Tests of Basic Skills Forms K L and M
Test Author: Hoover-H; Ilieronymous-A; N; Frisbie-D; A; Dunbar-S; B
Publication Date: 1955-1996
Reviewer: Brookhart-Susan-M; Cross-Lawrence-H
Review Indicator: 2 reviews available
Publisher: The Riverside Publishing Company 8420 Bryn Mawr Ave Chicago IL 60631
Acronym: ITBS
Mental Measurements Yearbook: 13 Mental Measurements Yearbook
Accession Number: 13012057

Purpose
"To provide a comprehensive assessment of student progress in the basic skills."

Population
Grades K.1-1.5, K.8-1.9, 1.7-2.6, 2.5-3.5, 3, 4, 5, 6, 7, 8-9...LE-10: 5, 6, 7, 8, 9, 10, 11, 12, 13, 14.

Scores

Time
(130-310) minutes for Complete Battery; (100) minutes for Survey Battery

Comments
Part of Riverside's Integrated Assessment System; Braille and large-print editions available
Appendix N

POPS Test Review
Test Name: Profiles of Problem Solving
Test Author: Stacey-Kaye; Groves-Susie; Bourke-Sid; Doig-Brian
Publication Date: 1993
Scores: 5: Correctness of Answer, Method Used, Accuracy, Extracting Information, Quality of Explanation
Reviewer: McLellan-Mary-J; Medina-Diaz-Maria
Review Indicator: 2 reviews available
Publisher: Australian Council for Educational Research 19 Prospect Hill Road Private Bag 55 Camberwell Victoria 3124 Australia
Acronym: POPS
Mental Measurements Yearbook: 13 Mental Measurements Yearbook
Accession Number: 13081532

Purpose

"An assessment of mathematical problem solving designed for children in upper primary school".

Population

Grades 4-6.

Price

1993 price data: $75 per manual and photocopiable masters.

Administration

Group

Scores

5: Correctness of Answer, Method Used, Accuracy, Extracting Information, Quality of Explanation.

Manual

Manual, 1993, 64 pages

Time

[32]40 minutes

Comments
Appendix O

Hands-On Problem Solving Test
Appendix P

Curriculum for Computer Troubleshooting Training Sessions
Week 1:
Day 1: Pre-Testing
Day 2: Pre-Testing/Getting to Know You and the Computer
Day 3: Lesson 1: Outer Hardware, Intro to Hardware on the Inside
Day 4: Lesson 2: Hardware on the Inside
Day 5: Lesson 3: Storage, Files and Folders, The Windows Desktop

Week 2:
Day 1: Lesson 4: Knowing Your System, Programs, Operating Systems, Computer Care and Safety
Day 2: Lesson 5: Troubleshooting Real Problems
Day 3: Post-Testing
Day 4: Post-Testing
Appendix Q

Procedure to Obtain Consent
Procedure to Obtain Consent Signature

I. Researcher informs students and parents of project through the initial letter.

II. Parents/students submit permission slip to participate in the testing, participate in the program, or to participate in neither.

III. Researcher agrees to answer any questions parents or students may have.

IV. If parent wishes to sign the Parental Consent Form:
   A. Researcher provides a copy to sign and a copy for the parent to keep.
   B. Researcher discusses early morning training and how it is pertinent that the student be on time everyday at 8:00am.

V. If parent does not wish to sign the Parental Consent Form, there is no further action taken.
Appendix R

Master’s Thesis Timeline
## Master’s Thesis Timeline

<table>
<thead>
<tr>
<th>Task</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Literature Review</td>
<td>January 2003-March 2003</td>
</tr>
<tr>
<td>2. Summaries of Articles</td>
<td>March 15(^{th}), 2003</td>
</tr>
<tr>
<td>3. Research Grant Funding Proposal</td>
<td>March 17(^{th}), 2003</td>
</tr>
<tr>
<td>4. Proposal</td>
<td>March 31(^{st}), 2003</td>
</tr>
<tr>
<td>5. Graduation Audit</td>
<td>March 31(^{st}), 2003</td>
</tr>
<tr>
<td>6. HSIRB</td>
<td>April 1(^{st}), 2003</td>
</tr>
<tr>
<td>7. Meeting with Thesis Committee</td>
<td>April 7(^{th}), 2003</td>
</tr>
<tr>
<td>8. Obtain Approval for Master’s Research Class</td>
<td>April 7(^{th}), 2003</td>
</tr>
<tr>
<td>9. Final Development of Curriculum</td>
<td>April 17(^{th}), 2003</td>
</tr>
<tr>
<td>10. Distribute permission slip for testing (Subject Recruitment Letter should be attached)</td>
<td>May 12(^{th}), 2003</td>
</tr>
<tr>
<td>11. Consent form/permission slip returned for participation in computer training</td>
<td>May 13(^{th}) – May 16(^{th}), 2003</td>
</tr>
<tr>
<td>12. Pre-assessment of Control and Experimental Groups</td>
<td>May 19(^{th}), 2003</td>
</tr>
<tr>
<td>13. Begin 1(^{st}) week of training with experimental group:</td>
<td>May 19(^{th}), 20(^{th}), 21(^{st}), 22(^{nd}), and 23(^{rd}) 2003</td>
</tr>
</tbody>
</table>

**Day 1:** Testing/Getting to Know You and the Computer

**Day 2:** Lesson 1: Outer Hardware, Intro to Hardware on the Inside

**Day 3:** Lesson 2: Hardware on the Inside

**Day 4:** Lesson 3: Bits and Bytes, Storage, Files and Folders, The Windows Desktop

**Day 5:** Lesson 4: Knowing Your System, Programs,
<table>
<thead>
<tr>
<th>Operating Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>14. Begin 2&lt;sup&gt;nd&lt;/sup&gt; week of training with experimental group:</td>
</tr>
<tr>
<td><strong>Day 1: Lesson 5: Computer Care and Safety</strong></td>
</tr>
<tr>
<td><strong>Day 2: Lesson 6: Intro to Troubleshooting Real Problems</strong></td>
</tr>
<tr>
<td><strong>Day 3: Lesson 7: Troubleshooting Real Problems</strong></td>
</tr>
<tr>
<td><strong>Day 4: Final Review</strong></td>
</tr>
<tr>
<td><strong>Day 5: Final Testing</strong></td>
</tr>
<tr>
<td>15. Post-assessment of Control and Experimental Groups</td>
</tr>
<tr>
<td>16. Chapter 1 – Introduction, Chapter 2 – Literature Review, Chapter 3 – Methodology</td>
</tr>
<tr>
<td><em>(Committee Meeting with Dr. Poole, Dr. Bosco and Dr. Leneway)</em></td>
</tr>
<tr>
<td>17. Chapter 4 – Results Chapter 5 – Discussion and Implications</td>
</tr>
<tr>
<td><em>(Committee Meeting with Dr. Poole and Dr. Leneway)</em></td>
</tr>
<tr>
<td>18. Meeting with Dr. Poole on Final Wrap-Up #1</td>
</tr>
<tr>
<td>19. Meeting with Dr. Poole and Dr. Leneway for Final Wrap-Up #2</td>
</tr>
<tr>
<td>20. Thesis Defense</td>
</tr>
<tr>
<td>21. Thesis Due Date</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Event</th>
<th>Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 26&lt;sup&gt;th&lt;/sup&gt;, 27&lt;sup&gt;th&lt;/sup&gt;, 28&lt;sup&gt;th&lt;/sup&gt;, 29&lt;sup&gt;th&lt;/sup&gt; and 30&lt;sup&gt;th&lt;/sup&gt;, 2003</td>
<td></td>
</tr>
<tr>
<td>May 30&lt;sup&gt;th&lt;/sup&gt;, 2003</td>
<td></td>
</tr>
<tr>
<td>June 3&lt;sup&gt;rd&lt;/sup&gt;, 2003 10:30 am</td>
<td></td>
</tr>
<tr>
<td>June 12&lt;sup&gt;th&lt;/sup&gt;, 2003 10:30 am</td>
<td></td>
</tr>
<tr>
<td>June 19&lt;sup&gt;th&lt;/sup&gt;, 2003</td>
<td></td>
</tr>
<tr>
<td>July 3&lt;sup&gt;rd&lt;/sup&gt;, 2003</td>
<td></td>
</tr>
<tr>
<td>July 9&lt;sup&gt;th&lt;/sup&gt;, 2003 11:00 pm – 1:00 pm Room 3208</td>
<td></td>
</tr>
<tr>
<td>July 18&lt;sup&gt;th&lt;/sup&gt;, 2003</td>
<td></td>
</tr>
</tbody>
</table>
Appendix S

Paired Samples T-Test Results
### All Students T-Test Pre and Post

#### Paired Samples Statistics

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>25.4167</td>
<td>12</td>
<td>7.26709</td>
<td>2.09783</td>
</tr>
<tr>
<td>POPS: Total: Pre</td>
<td>28.4167</td>
<td>12</td>
<td>9.89452</td>
<td>2.85630</td>
</tr>
</tbody>
</table>

#### Paired Samples Correlations

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Correlation</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>12</td>
<td>.814</td>
<td>.001</td>
</tr>
</tbody>
</table>

#### Paired Samples Test

<table>
<thead>
<tr>
<th></th>
<th>Paired Differences</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>-3.0000</td>
<td>5.79969</td>
<td>-6.6849 to .6849</td>
<td>-1.792</td>
</tr>
</tbody>
</table>

### Control T-Test Pre and Post

#### Paired Samples Statistics

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>25.5000</td>
<td>6</td>
<td>8.24015</td>
<td>3.36403</td>
</tr>
<tr>
<td>POPS: Total: Pre</td>
<td>25.8333</td>
<td>6</td>
<td>9.74508</td>
<td>3.97841</td>
</tr>
</tbody>
</table>

#### Paired Samples Correlations

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Correlation</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>6</td>
<td>.793</td>
<td>.060</td>
</tr>
</tbody>
</table>
### Paired Samples Test

<table>
<thead>
<tr>
<th>Pair</th>
<th>POP5: Total: Pre - POP5: Total: Post</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>Lower</th>
<th>Upper</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-0.3333</td>
<td>5.9539</td>
<td>2.4318</td>
<td>-6.5831</td>
<td>5.9165</td>
<td>-1.37</td>
<td></td>
</tr>
</tbody>
</table>

### Paired Samples Test

<table>
<thead>
<tr>
<th>Pair</th>
<th>POP5: Total: Pre - POP5: Total: Post</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>5</td>
<td>0.896</td>
</tr>
</tbody>
</table>

### Experimental T-Test Pre and Post

#### Paired Samples Statistics

<table>
<thead>
<tr>
<th>Pair</th>
<th>POP5: Total: Pre - POP5: Total: Post</th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>25.3333</td>
<td>6</td>
<td>6.9496</td>
<td>2.83428</td>
</tr>
<tr>
<td></td>
<td></td>
<td>31.0000</td>
<td>6</td>
<td>10.2176</td>
<td>4.17133</td>
</tr>
</tbody>
</table>

#### Paired Samples Correlations

<table>
<thead>
<tr>
<th>Pair</th>
<th>POP5: Total: Pre &amp; POP5: Total: Post</th>
<th>N</th>
<th>Correlation</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>6</td>
<td>0.924</td>
<td>0.008</td>
</tr>
</tbody>
</table>

#### Paired Samples Test

<table>
<thead>
<tr>
<th>Pair</th>
<th>POP5: Total: Pre - POP5: Total: Post</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>-5.6667</td>
<td>4.6332</td>
<td>1.89150</td>
<td>-10.5889</td>
<td>-2.996</td>
</tr>
</tbody>
</table>

#### Paired Samples Test

<table>
<thead>
<tr>
<th>Pair</th>
<th>POP5: Total: Pre - POP5: Total: Post</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>5</td>
<td>0.030</td>
</tr>
</tbody>
</table>
### Means

#### Case Processing Summary

<table>
<thead>
<tr>
<th></th>
<th>Included</th>
<th></th>
<th>Excluded</th>
<th></th>
<th>Total</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Percent</td>
<td>N</td>
<td>Percent</td>
<td>N</td>
<td>Percent</td>
</tr>
<tr>
<td>POPS: Total: Pre</td>
<td>12</td>
<td>100.0%</td>
<td>0</td>
<td>.0%</td>
<td>12</td>
<td>100.0%</td>
</tr>
<tr>
<td>GROUP * GENDER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>POPS: Total: Post</td>
<td>12</td>
<td>100.0%</td>
<td>0</td>
<td>.0%</td>
<td>12</td>
<td>100.0%</td>
</tr>
<tr>
<td>GROUP * GENDER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Report

<table>
<thead>
<tr>
<th>GROUP</th>
<th>GENDER</th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>F</td>
<td>23.3333</td>
<td>3</td>
<td>8.14453</td>
<td>27.0000</td>
<td>3</td>
<td>8.54400</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>3</td>
<td></td>
<td></td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>Mean</td>
<td>27.6667</td>
<td>3</td>
<td>9.45163</td>
<td>24.6667</td>
<td>3</td>
<td>12.66228</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>3</td>
<td></td>
<td></td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Mean</td>
<td>25.5000</td>
<td>6</td>
<td>8.24015</td>
<td>25.8333</td>
<td>6</td>
<td>9.74508</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>6</td>
<td></td>
<td></td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Std. Deviation</td>
<td>8.24015</td>
<td>9.74508</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| E     | F      | 29.6667 | 3  | 7.57188       | 38.0000 | 3  | 7.54983       |
|       | N      | 3       |    |               | 3       |    |               |
| M     | Mean   | 21.0000 | 3  | 2.64575       | 24.0000 | 3  | 7.54983       |
|       | N      | 3       |    |               | 3       |    |               |
| Total | Mean   | 25.3333 | 6  | 6.94742       | 31.0000 | 6  | 10.21763      |
|       | N      | 6       |    |               | 6       |    |               |
|       | Std. Deviation | 6.94742 | 10.21763 |

| Total | Mean   | 25.4167 | 12 | 7.26709       | 28.4167 | 12 | 9.89452       |
|       | N      | 12      |    |               | 12      |    |               |
|       | Std. Deviation | 7.26709 | 9.89452 |

#### Both Pre and Post Test: Experimental vs. Control: T-Test

**Paired Samples Statistics**

<table>
<thead>
<tr>
<th>Pair</th>
<th>POPS:</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PRE_CONT</td>
<td>25.5000</td>
<td>8.24015</td>
<td>3.36403</td>
</tr>
<tr>
<td>Pair</td>
<td>PRE_EXP</td>
<td>25.3333</td>
<td>6.94742</td>
<td>2.83627</td>
</tr>
<tr>
<td>2</td>
<td>POST_CONT</td>
<td>25.8333</td>
<td>9.74508</td>
<td>3.97841</td>
</tr>
<tr>
<td>Pair</td>
<td>POST_EXP</td>
<td>31.0000</td>
<td>10.21763</td>
<td>4.17133</td>
</tr>
</tbody>
</table>
### Paired Samples Correlations

<table>
<thead>
<tr>
<th>Pair</th>
<th>Variable 1 &amp; Variable 2</th>
<th>N</th>
<th>Correlation</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>PRE_CONT &amp; PRE_EXP</td>
<td>6</td>
<td>-0.583</td>
<td>0.224</td>
</tr>
<tr>
<td>Pair 2</td>
<td>POST_CON &amp; POST_EXP</td>
<td>6</td>
<td>-0.538</td>
<td>0.271</td>
</tr>
</tbody>
</table>

### Paired Samples Test

<table>
<thead>
<tr>
<th>Pair</th>
<th>Paired Differences</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>PRE_CONT - PRE_EXP</td>
<td>.167</td>
<td>13.52652</td>
<td>5.52218</td>
<td>-14.0285 - 14.3619</td>
<td>0.977</td>
</tr>
<tr>
<td>Pair 2</td>
<td>POST_CON - POST_EXP</td>
<td>-5.167</td>
<td>17.50905</td>
<td>7.14804</td>
<td>-23.5413 - 13.2079</td>
<td>0.502</td>
</tr>
</tbody>
</table>

### Paired Samples Test

<table>
<thead>
<tr>
<th>Pair</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>.030</td>
<td>5</td>
<td>0.977</td>
</tr>
<tr>
<td>Pair 2</td>
<td>-.723</td>
<td>5</td>
<td>0.502</td>
</tr>
</tbody>
</table>
Appendix T

Michigan Curriculum Frameworks
Michigan Curriculum Frameworks for Technology

OVERVIEW OF TECHNOLOGY CONTENT STANDARDS

All students will:
Use and transfer technological knowledge and skills for life roles (family member, citizen, worker, consumer, lifelong learner);

Use technologies to input, retrieve, organize, manipulate, evaluate, and communicate information;

Apply appropriate technologies to critical thinking, creative expression, and decision-making skills;

Employ a systematic approach to technological solutions by using resources and processes to create, maintain, and improve products, systems, and environments;

Apply ethical and legal standards in planning, using, and evaluating technology; and

Evaluate the societal and environmental impacts of technology and forecast alternative uses and possible consequences to make informed civic, social, and economic decisions.

More detailed information concerning the technology standards can be found at: http://www.michigan.gov/documents/Technology_11594_7.htm

Standard 1.2 Variability and Change
Students describe the relationships among variables, predict what will happen to one variable as another variable is changed, analyze natural variation and sources of variability, and compare patterns of change.

Variability and change are as fundamental to mathematics as they are to the physical world, and an understanding of the concept of a variable is essential to mathematical thinking. Students must be able to describe the relationships among variables, to predict what will happen to one variable as another variable is changed, and to compare different patterns of change. The study of variability and change provides a basis for making sense of the world and of mathematical ideas.

**Strand III. Data Analysis and Statistics**

We live in a sea of information. In order not to drown in the data that inundate our lives every day, we must be able to process and transform data into useful knowledge. The ability to interpret data and to make predictions and decisions based on data is an essential basic skill for every individual.

**Standard III.1 Collection, Organization and Presentation of Data**

Students collect and explore data, organize data into a useful form, and develop skill in representing and reading data displayed in different formats.

Knowing what data to collect and where and how to collect them is the starting point of quantitative literacy. The mathematics curriculum should capitalize on students' natural curiosity about themselves and their surroundings to motivate them to collect and explore interesting statistics and measurements derived from both real and simulated situations. Once the data are gathered, they must be organized into a useful form, including tables, graphs, charts and pictorial representations. Since different representations highlight different patterns within the data, students should develop skill in representing and reading data displayed in different formats, and they should discern when one particular representation is more desirable than another.

**Standard III.3 Inference and Prediction**

Students draw defensible inferences about unknown outcomes, make predictions, and identify the degree of confidence they have in their predictions.

Based on known data, students should be able to draw defensible inferences about unknown outcomes. They should be able to make predictions and to identify the degree of confidence that they place in their predictions.

**Standard V.1 Operations and Their Properties**

Students understand and use various types of operations (e.g., addition, subtraction, multiplication, division) to solve problems. The ultimate reason for mastering the operations of arithmetic and algebra is to solve problems. To that end, understanding the basic computational operations and their algorithms is essential for competence in mathematics, but the emphasis must be on understanding and using the operations, not on memorizing algorithms. In computation, understanding and accuracy are always more important than speed. Understanding the operations requires the concomitant understanding and application of the properties of those operations, and it involves knowing ability to represent computations with manipulatives and geometric models; and the discernment of which computational method to use in a given situation. Computational methods also involve estimating and assessing the reasonableness of the results of a computation.

**Standard V.2 Algebraic and Analytic Thinking**

Students analyze problems to determine an appropriate process for solution, and use algebraic notations to model or represent problems.
Mathematical representations allow us to visualize and understand problems. These representations may be numerical, literal, symbolic, graphical, pictorial or physical. Facility with multiple representations of numerical and algebraic concepts and relationships is essential to mathematical competence. This includes the development of "symbol sense" as well as "number sense" and the understanding that the notion of solution involves a process as well as a product. Thus, the solution of a mathematical problem requires both an understanding of the question for which an answer is sought and the development of a strategy to obtain that answer. The context of the problem determines the nature and the degree of precision of the required solution. The increasing use of quantitative methods in all disciplines has made algebra the fundamental tool for mathematical applications. Algebraic thinking is learned most effectively when it is studied in the context of applications, both mathematical and real-world, that reveal the power of algebra to model real problems and to generalize to new situations. Students should use algebraic techniques to analyze and describe relationships, to model problem situations, and to examine the structure of mathematical relationships. The algebra curriculum should employ contemporary technology, including spreadsheets and graphical analysis, to emphasize conceptual understanding of algebra and analytic thinking as sophisticated means of representation and as powerful problem-solving tools.

Standard VI.2 Discrete Mathematics

Students investigate practical situations such as scheduling, routing, sequencing, networking, organizing and classifying, and analyze ideas like recurrence relations, induction, iteration, and algorithm design. Discrete (discontinuous) mathematics has grown in significance in recent years and today has applications in many important practical situations such as scheduling, routing, sequencing, networking, organizing and classifying. Important ideas like recurrence relations, induction and algorithm design also have practical applications in a variety of fields. Computers, which are finite, discrete machines, require an understanding of discrete mathematics for the solution of problems using computer methods.
Appendix U

Typical 5th Grade Problem Solving by NTCM
Typical 5th Grade Problem Solving Ability

Reflecting on different ways of thinking about and representing a problem solution allows comparisons of strategies and consideration of different representations. For example, students might be asked to find several ways to determine the number of dots on the boundary of the square in figure 2.1a and then to represent their solutions as equations (Burns and McLaughlin 1990).

![The "dot square" problem](image)

Students will likely see different patterns. Several possibilities are shown in figure 5.28. The teacher should ask each student to relate the drawings to the numbers in their equations. When several different strategies have been presented, the teacher can ask students to examine the various ways of solving the problem and to notice how they are alike and how they are different. This problem offers a natural way to introduce the concept and term equivalent expressions.

In addition to developing and using a variety of strategies, students also need to learn how to ask questions that extend problems. In this way, they can be encouraged to follow up on their genuine curiosity about mathematical ideas. For example, the teacher might ask students to create a problem similar to the "dot square" problem or to extend it in
some way: If there were a total of 76 dots, how many would be on each side of the square? Could a square be formed with a total of 75 dots? Students could also work with extensions involving dots on the perimeter of other regular polygons. By extending problems and asking different questions, students become problem posers as well as problem solvers.

Fig. 2.1b Several possible solutions to the "dot square" problem
Appendix V

Email Documentation from Kids Domain.Com
Thank you for your request. By all means, please feel free to model your computer curriculum after the lessons on Kids Domain. Please include acknowledgment of our website if you reprint and handout any of our content.

We hope that you will continue to enjoy all that the Kaboose Network has to offer.

Kind regards,

The Kaboose Team

http://www.kaboose.com

The Kaboose Network - Get On Board!

Funschool.com - KidsDomain.com - Zeeks.com

--
Appendix W

Spreadsheets of Answers for Worksheets and Worksheet Samples
Station #6: Laptop Trauma

I lost a file! I saved a file, but I can’t remember what I called it. I know the title at the top of the page was:

Lost Dog

Can you find it for me? Where was it?

While you’re finding my file, I need my background changed. Is there any way you can change my background on the desktop? How did you do it?

Station #1

Team #1: “Plug in printer and put in paper.”

Team #2: First it wasn’t plugged in and the USB wasn’t plugged in. There was no paper. The printer was not plugged in to the [monitor].”
Team #3: “What’s wrong with your printer is the plug wasn’t in and there was no paper. So you need to put some in.”

Station #2
Team #1: “Plug in any plugs, put in CD and pushed yes, You put the CD in and clicked on yes to install it.”
Team #2: “One problem we had was the mouse was not plugged in. We first went to installer then we pushed continue and it installed them. We restarted the computer.”
Team #3: Did not complete due to time constraints.

Station #3
Team #1: “Monitor won’t turn on because it had no power and it was not plugged in to the power tower.”
Team #2: “The monitor is not working. It is not working because the [monitor] is not plugged into the power tower.”
Team #3: “[The problem is the] monitor won’t turn on because the power cable isn’t plugged into the monitor.”

Station #4
Team #1: “The sound cable is not plugged in. The ram is missing. The trackball for the mouse isn’t in. Plug in [the] mouse, keyboard and monitor. The power cable is not plugged in.
Team #2: “The ram is missing (1). The wire is not plugged in. The p5 (the internal power cord) wire is not plugged in. The [monitor] is not plugged into the power tower.”
The mouse is not plugged in. The trackball is missing. The power button is not there.
The power cord.”

Team #3: “Sound cable. More ram. Trackball. Plug in mouse and keyboard and
monitor and power cable plug in.”

Team #1: “You could not do anything or hear anything.”

Team #3: “You could [not do] anything or [hear] anything.”

Station #6

Team #1: “It is under Microsoft Word.”

Team #2: “Yes we found it. We went to search and pushed files and folders then we
typed in lost dog.”

Team #3: “It was in Microsoft Word.”

Team #1: “You right click anywhere then you click properties. Then you go to desktop
and change the background.”

Team #2: “Yes. We right clicked then we went to properties. Then we clicked on
desktop and changed it.”

Team #3: “Yes. I went under desktop and found it.”