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# A Comparison of Reading Comprehension and Problem Solving Abilities

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A COMPARISON OF READING COMPREHENSION

AND

PROBLEM SOLVING ABILITIES

By

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Recommendations of the National Council of Teachers of Mathematics and the Washington State Commission on Student Learning Essential Academic Requirements are addressed. Reading comprehension and problem solving skills of 9th grade students at Zillah High School are compared to see if a correlation between these two abilities exists. Recommendations for creating and implementing a curriculum are given.

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# CHAPTER ONE

# BACKGROUND OF THE PROJECT

## Introduction

Mathematics is an essential part of the school curriculum. "Even more important is the student's need to learn mathematical concepts and how to apply them" (Chinnappan, 1996, p. 141). Many of our schools today put a great deal of emphasis on computing and basic mathematical basic facts when in reality many adults use calculators and computers to solve computational problems. Although computing basic facts is important, the need to help children develop problem-solving skills is increasing rapidly. In 1993, the President's National Commission on Excellence in Education felt more emphasis needed to be put on problem solving. The Commission recommended that the eight grades leading to high school should provide a sound basis in computational and problem solving skills. The Commission also suggested that applying mathematics in everyday situations should be one of the four areas of mathematics studied in high school. According to Mikusa (1998), students need to experience problems that are relevant to their life and may take hours or days to solve.

The National Council of Teachers of Mathematics (NCTM) has recommended that problem solving be a primary focus of school mathematics in the 1990s. The

NCTM stated, “problem solving is essential to the day to day living of every citizen” (NCTM, 1989, p. 1). Schools need to show children not only how to do mathematics, but more importantly how to use mathematics in real situations.

With this focus on mathematics and problem solving a redefinition of school mathematics curricula and instruction has been taking place over the past decade. Mathematics education is moving away from the outdated and simplistic behaviorist learning theory that has dictated the course of mathematics teaching for more than forty years. According to Battista (1988) “all of the major scientific theories describing students’ mathematics learning agree that the students must personally construct mathematical ideas as they try to make sense of the situations”(p. 428). With this change in beliefs about how students learn mathematics, many states are moving away from traditional multiple choice tests and incorporating tests that use a combination of multiple choice, short answer, and extended answer questions to assess the students’ ability in mathematics.

Currently in Washington State the major focus in mathematics testing is on open-ended problem solving questions. In 1993 the State of Washington began to construct new student learning goals called the Essential Academic Learning Requirements (EALRs). In 1997 the first test of the ELARs was administered in the fourth grade and the results showed student scores were extremely low across the State of Washington. With this new type of testing one of the major areas of concern was mathematics. Students throughout the state were scoring below the grade level standard in mathematics. In the school district in which the author teaches, only three fourth grade students out of 98 earned a score high enough to pass the mathematics section of the test (Busey, 1999). Although scores were low there were still many students who were quite competent at problem solving. What factor(s) might have enhanced these students' problem-solving abilities? What made these students better at problem solving than other students?

With these questions in mind, creating a curriculum that will enhance students' abilities in problem solving is a task that has many different possible directions. Problem solving involves being able to comprehend the problem, creating a process for solving the problem and calculating numbers correctly to arrive at a solution. According to Mikusa (1998) the goal of the classroom teacher is to create opportunities for the students to reason and explore the relationships among concepts so they will construct knowledge that will allow them to extend what was learned in lessons in ways that enables them to solve new problems.

## Purpose of the Project

The purpose of this project is to examine the relationship between students' reading comprehension level and their ability to solve mathematical open-ended word problems. The project will focus on the correlation between students' reading comprehension and problem solving as defined by the EALRs recently implemented in Washington State. The reason the author chose to look specifically at word problems was that this is the area on the Washington Assessment of Student Learning test where students have the most difficulty. In addition, recommendations for adjusting and implementing a curriculum are given.

## Significance of the Project

The reason the author chose to look specifically at mathematical open-ended problem solving is because the school district in which the author is employed is aligning the mathematics curriculum with the current EALRs. Within the author's district math scores are low and many people want to know how to increase students' problem solving abilities so as to increase their state scores. This project explores whether there is a correlation between students' reading level and their ability to solve open ended word problems to see if there is a need to adjust the current curriculum to include a reading comprehension component.

## Limitations of the Project

Research in the area of reading comprehension combined with mathematical problem solving is limited. The project is also limited to one area of mathematics, problem solving. Another limitation is that this project will focus on one particular aspect of problem solving, comprehension and solving word problems. Also, only the problem solving abilities and reading comprehension levels of ninth grade algebra students will be correlated.

Definition of Terms

The terms used in this project are to clarify the author's meaning.

Word Problem: A quantitative situation involving words in which mathematical questions are asked, but the operation needed to solve the problem is not indicated.

Essential Academic Learning Requirements (EALRs): These are the state standards of achievement for students in the public school system. (Washington State Commission on Student Learning, 1997)

Reading comprehension level: This is the grade level at which the student can comprehend the written word.

Overview of the remainder of the project

Chapter Two is a review of relevant literature pertaining to the importance of problem solving and reading comprehension. Chapter Three describes the procedures undertaken to develop the project. Chapter Four is the project data itself: a comparison of reading comprehension levels and problem solving abilities. Chapter Five consists of a summary, conclusions, and recommendations by the author.

# CHAPTER TWO

# REVIEW OF RELATED LITERATURE

## Introduction

This chapter will review previous research in problem solving at the secondary level. The focus of this project is on reading comprehension and basic mathematical skills and how they correlate with a student's problem solving abilities. The literature reviewed here deals with mathematical problem solving and the benefits of reading comprehension abilities.

## The Importance of Problem Solving

The need for children to become proficient problem solvers has been a key issue for educators. The National Council of Teachers of Mathematics (NCTM) (1989) has recommended that problem solving be the number one focus of school mathematics in the 1990s. The NCTM also stated that, "The curriculum needs to emphasize use of skills, not just computation" (1989, p. 1). The NCTM reported that the classroom teacher should provide an environment where the student can practice problem solving. The teacher should select appropriate problems to open their minds and curiosity, help them to become willing to probe and to try to make intelligent guesses. The NCTM also suggested that problem solving be taught to all ages and in all curriculum areas. The NCTM feels that reading in mathematics is important so children can actively explore, investigate, describe and explain mathematical ideas.

Burns (1997) agrees with the NCTM in stating, "It would be hard for anyone to deny that the major responsibility of schools is to help children become effective problem solvers, preparing them to face the myriad of day to day problems they'll face as adults" (p. 72).

Burns (1997) stresses that teachers spend too much time on arithmetic and not enough on application or practical purposes. Teachers need to help students focus on the meaning involved and not just the answer. Andrews (1999) believes that the concepts and the relationships involved in a problem are what make it difficult for most children, not the actual computation. Another problem Andrews sees is the conception teachers have about mathematics and how it should be taught. Many teachers were taught in the drill and kill era and that is the only method of instruction they know. If students are to become effective problem solvers teachers must change their conceptions about mathematics (Andrews, 1999).

In the real world when most adults are faced with an arithmetic problem they usually do the computations with a calculator, but how do they approach a problem if they have not been taught how to solve it? Battista (1999) believes people need to be able to use their minds as well as their knowledge of mathematics. People need to see mathematics not as just the simple calculations of numbers, but rather as a tool to be used to reason with real-world situations. Through understanding problems they will be able to apply their mathematical knowledge to new unsolved problems as they come across them each day.

Mathematics involves much more than just the basic operations. Students need to learn to solve problems so they can apply this to their daily lives. Bernardo (1999) feels learning to solve problems is the principle reason for projecting mathematics. If educators believe this to be true then they need to focus on problem solving and how to effectively teach it. In Bernardo's words "the most basic difficulty students have in solving word problems lies in the ability to understand the mathematical problem structure that is embedded in the problem text" (p. 149).

Word problems are an integral component of problem solving. Quinn (1997) claims word problems are the first step in problem solving. "The child who gains the knowledge of how to use an operation, together with when to use an operation is developing the skills needed to become an efficient problem solver" (p. 536). Quinn also feels that many students fail to realize that word problems are just a small part of problem solving, understanding the problem and discovering the equation is the main focus of problem solving.

According to Mikusa (1998) word problems provide a setting for the operation, practicing the operation, showing pupils mathematics is significant and emphasizing a relationship of operations. The goal for most students is simply to get an answer. If they cannot find the correct answer the students feel that it is up to the teacher to show them the proper way to go about solving the problem. Mikusa (1998) believes that in order for students to become effective problem solvers, they must engage problems that may take days for them to solve. This extended problem solving requires the students to use reflective thinking, which is critical skill in problem solving. In order for this extended problem solving to take place traditional ways of teaching mathematics must change and teachers must begin to instruct students on the techniques used in solving difficult word problems. Mikusa (1998) feels that teachers need to be more concerned with the subtle qualitative changes in students rather than the number of problems correctly completed.

## The Essential Academic Learning Requirements

In 1992, the Washington State legislature passed the Education Reform Act. The legislature created and changed the Commission on Student Learning to develop statewide student performance standards called the Essential Academic Learning Requirements (EALRs). The EALRs were based on the Student Learning Goals of the Governor's Council on Education Reform and Funding.

The EALRs in mathematics contain components, which are necessary for students to learn if they are to become confident and proficient at mathematics. These components are becoming the framework on which the teachers of Washington must build their mathematics curriculum. The EALRs in mathematics, as of September of 1998, are as follows.

1) The student understands and applies the concepts and procedures of mathematics.

To meet this standard the student will:

a) Understand and apply concepts and procedures from number sense.

b) Understand and apply concepts and procedures from measurement.

c) Understand and apply concepts and procedures from geometric sense.

d) Understand and apply concepts and procedures from probability and statistics.

e) Understand and apply concepts and procedures from algebraic sense.

2) The student uses mathematics to define and solve problems.

To meet this standard the student will:

a) Investigate situations

b) Formulate questions and define the problem

c) Construct solutions

3) The student uses mathematical reasoning.

To meet this standard the student will:

a) Analyze information

b) Predict results and make inferences

c) Draw conclusions and verify results

4) The student communicates knowledge and understanding in both everyday and mathematical language.

To meet this standard the student will:

a) Gather information

b) Organize and interpret information

c) Represent and share information

5) The student understands how mathematical ideas connect within mathematics, to other subject areas, and to real-life situations.

To meet this standard the student will:

a) Relate concepts and procedures within mathematics

b) Relate mathematical concepts and procedures to other disciplines

c) Relate mathematical concepts and procedures to real life situations

(Commission on Student Learning, 1997, p. 22).

The EALRs are designed to help guide schools and parents in giving their students the knowledge and skills necessary to lead successful lives and contribute to their family and community. The development of the EALRs started in 1992 and is continually being reviewed and updated to insure that students are being given the best opportunities possible.

The Importance of Reading Comprehension

Many experts believe that reading comprehension skills are related to problem solving abilities in mathematics; however Bernardo (1999) points out mathematical word problems have troubled both students and teachers for generations. "The most basic difficulty students have in solving word problems lies in the ability to understand the mathematical problem structure that is embedded in the problem text" (Bernardo, 1999, p. 149). There have been several reasons cited for this difficulty. Among the most common are the student does not understand what the problem is asking, what operations will produce the answer, and general lack of interest in word problems (Chinnappan, 1996).

Reading and writing have been reported to aid in the development of cognitive skills. Linn (1987) believes that metacognitive ability is strengthened when the student views the learning process as active, constructive, cumulative, and goal oriented. Pugalee (1994) feels that reading and writing helps build thinking skills for mathematics students as they become accustomed to reflecting and synthesizing as parts of the normal sequence involved in communicating mathematics. This skill of reflective thinking is a vital part of creating mathematical problem solving abilities in students. The Three Level reading guide has been used and recommended by teachers and researchers for over two decades. According to Conley and Savage (1995) a Three Level Reading guide contains declarative statements written to require student responses at the literal, interpretive, and applied levels of comprehension. At the literal level, students place checks next to the statements that are explicit in the text. Statements at the interpretive level are checked if they could be supported by implicit relationships among explicit text statements. At the applied level, students are encouraged to integrate the new literal and interpretive information with their own prior knowledge. By building reading comprehension skills students have the opportunity to become independent problem solvers, which should be the goal of all mathematics teachers (McIntosh, 1997).

Students often believe that mathematics involves only numbers and abstract symbols. According to Fuentes (1998) "students often forget that mathematics involves natural thought and language processes as well numbers and symbols" (p. 81). Fuentes believes teaching students the language of mathematics and how to reflect on previous work, the student will help them develop a well-rounded concept of what mathematics is all about. Fuentes also believes that all students want to be successful. The main problem is educators are neglecting the students' needs by not giving them the tools to become successful problem solvers.

Teachers often find themselves teaching their subjects with no recognition that attention to comprehension would enhance the students learning. One way that Fuentes suggests mathematics teachers can promote reading comprehension is by opening up the channels of communication in the classroom beyond the written channel. Teachers should encourage students to openly share ideas and learn concepts by reading, writing, talking, exploring and talking together (Fuentes, 1998).

Krussel (1998) feels the first step in teaching students how to solve word problems is to make them feel secure about their mathematic abilities. Krussel states "It is important to get across to students that a problem is a situation that they do not know the answer to. Therefore it is O.K. to not know the answer, or it isn't a problem" (p. 437). If students can understand this view of a word problem then the teacher can help them to feel secure in trying to solve word problems. After students are comfortable with their problem solving abilities Krussel (1998) believes students should be taught to view mathematics as a separate language. Krussel states, "reading and speaking mathematically differ from reading and speaking English prose because mathematics has a special logic and syntax" (p. 438). If teachers instruct students how to read the language of mathematics, problem solving then becomes an issue of comprehension and calculation. If students are to become proficient in reading the language of mathematics Krussel feels that teachers must encourage, if not require, the students to use the terminology found in mathematics.

Along with being able to read mathematics Wakefield (1997) believes students also need the opportunities to mimic and practice relevant mathematic problems. Wakefield maintains, "the teacher who wishes to develop his students to solve word problems, must instill some interest into their minds and give them plenty of opportunity for imitation and practice" (p. 233). Interest and practice are very important in teaching a child how to solve word problems. The more practice students' have reading, comprehending and solving word problems, the more confidence they will develop in this area of mathematics (Wakefield, 1997).

Chinnappan and Lawson (1999) maintain "students fail to activate and use mathematical knowledge during problem solving, when it is known that they possess the required knowledge" (p. 140). Much of what a student learns in a mathematics classroom is the process in which to use when faced with a particular problem. This process is well known by the student, but when and how to apply it is the student's major difficulty. Chinnappan and Lawson believe one of the reasons students do not access knowledge they possess is because they do not understand the problem they are faced with. One of the solutions they give to combat this problem of understanding is to work on reading comprehension of mathematics (Chinnappan & Lawson, 1999).

Manning (1999) also believes one of the major reasons for not understanding a word problem is lack of reading skills (p. 85). In a mathematics word problem, students need to understand the meaning of each word within the problem. Word problems involve the simultaneous act of using two separate language systems, both requiring thinking. Manning (1999) believes word problems necessitate reading while at the same time thinking abstractly about mathematics. Manning also believes that one of the best ways to get students to think is by asking them questions and having them defend their view points with logical arguments.

Another reason that students do not understand word problems is the lack of understanding of mathematical terminology. The students do not regularly use the vocabulary used in the word problems and they do not know what the words mean (Fuentes, 1998). When solving word problems students must extract the required information from the reading and use this information to solve a word problem. The student needs to be able to state what is happening, discover what is given, eliminate the extra information, find any hidden information, and realize what is wanted in order to solve the problem (Ostler, 1997). Once the student can understand the meaning of the words, he or she can then work on understanding the question and what operation to use.

## Summary

Researchers and educators alike feel that mathematics education is changing rapidly. Mathematics involves much more than just the basic operations. Students are now being required to use problem solving skills, rather than completing simple mathematical operations. Experts believe that in order for students to be successful in life they need to learn to solve problems so they can apply this to their daily lives.

With today's changing world students now need more problem solving skills than ever before. Because of these changes many states are changing the way students are tested. In Washington State the EALRs were created and every student is tested on these new state standards. A higher standard for the students means a change in the current curriculum. These changes in curriculum should help students as they work towards meeting the Washington state EALRs.

With the need for changing the mathematics curriculum, teachers are now finding that techniques used in other curricular areas are becoming valuable tools in the mathematics classroom. Many experts believe that teaching reading comprehension skills in mathematics can enhance students' learning in mathematics. The strategies that other subject areas are using to stimulate thought in students, needs to be incorporated into the mathematics curriculum.

# CHAPTER THREE

# PROCEDURES

## Introduction

The project originated because of the author's desire to enhance his student's mathematical performance on the new Washington Essential Academic Learning Requirements (EALRs). The school district in which the author is employed is currently aligning its curriculum with the new EALRs. The need to align the curriculum with the EALRs arose after low student test scores were reported on the first state test. Many people in the author's district believe one of the reasons for the low test scores in mathematics is because of the inability of the students to comprehend the word problems on the Washington Assessment of Student Learning test (WASL). While trying to align the mathematics curriculum many questions arose about what changes should be made in the curriculum to help meet the needs of students. Because of these questions the author decided to conduct a small project that correlated reading comprehension levels with problem solving scores. It was hypothesized, for the purposes of this project, that the reading comprehension level of a student would not correlate with their mathematics score on a sample WASL test. A project was conducted to test this hypothesis. With the information gathered from this project the author will make recommendations to the district about what adjustments need to be made to better serve our students in the area of mathematics.

## Subjects

The project included twenty students randomly selected from the high school's freshman class. After the subjects were selected the author, to see if they would participate in the project, contacted them. Only two of the original twenty subjects declined to participate. Two replacement subjects were obtained through the same random selection process.

## Testing Instruments and Procedures

After the selection process each student was tested in reading comprehension and mathematical problem solving. The testing instruments used were the Woodcock-Johnson reading test (Woodcock, 1989) and a problem-solving test produced by Washington State. The problem-solving test is a sample test composed of questions (See Appendix B) typical of those on the Washington Assessment of Student Learning (WASL) test (Commission on Student Learning, 1999). In addition, approval for the project was obtained from the superintendent and a parent/student permission letter (See Appendix A) was approved by the principal and sent home with each participating student. Upon receiving the permission letter a phone call to the parents or guardian of the participating student was placed to verify the permission verbally.

The Woodcock-Johnson test is a series of questions given to a student in a one-on-one setting. This test is widely used by special education and general education professionals to determine the reading grade levels of students. The procedure for administering this test is as follows: The proctor gives the student a question, and then based on the student's response another question is selected and given. This process continues until an accurate assessment of the student's reading comprehension level is obtained. After the student's reading grade level is determined he or she takes the problem-solving test.

The problem-solving test to be used in this project is a sample test given to many school districts to help prepare teachers and students for the types of test questions they will encounter. This sample test comes with scoring rubrics, answer keys, and anchor papers to be used to compare sample student answers with actual student answers (Commission on Student Learning, 1999) (See Appendix B).

Each student involved in the project was given the Woodcock-Johnson test first. The test was given in the author's classroom after the regular school day had ended. After all of the students had been tested for their reading comprehension level the problem-solving portion of the test was administered. The problem-solving test was given in several small groups on scheduled days after the regular school day ended. The mathematics tests were then scored and then organized by student identification number. After the data were organized several attempts to correlate the scores were made using different correlation techniques found in the book, Educational Research (Gay, 1996). The first two methods were the Chi-Square and *T*-test. These instruments were unsuccessful because the data collected on the reading and mathematics test were not similar in nature (p. 328). The next instrument used to find the correlation coefficient was the Spearman rho. This instrument was discarded because the resulting correlation coefficient was not as accurate with small groups of subjects (less than 30) (p. 302). Finally a correlation of the scores was conducted using the Pearson *r* correlation method. The reason the Pearson *r* was used is because it is the most appropriate measure of correlation when sets of data to be correlated represent either interval or ratio scales (p. 302). The Pearson *r* correlation is the ratio of the degree of variation of X and Y together to the degree of the separate variation of X and Y. In lay terms this instrument is based on a scatter plot and linear regression analysis. The data were then displayed using a scatter plot. A linear regression was used to see if any relationship existed between the students' reading comprehension level and their problem-solving abilities.

# CHAPTER FOUR

# RESULTS OF THE PROJECT

## Purpose of the Project

The purpose of this project is to examine the relationship between students' reading comprehension level and their ability to correctly answer Washington Assessment of Student Learning (WASL) math test questions. The project focuses on the correlation between students' reading comprehension and problem solving as defined by the Essential Academic Learning Requirements (EALRs) recently implemented in Washington State. The reason the author chose to look specifically at word problems was that this is the area on the WASL test where students within the author's school district have the most difficulty (Busey, 1999).

## Subjects

The subjects for this project were high school freshman. Chronological ages ranged from 14 to 15 years old. All subjects were randomly selected from the official high school class roster. All students were given a permission form to have their parents sign and upon its return a phone call to the parents was made by the author to confirm the participation of the student. The permission form used for this project was created by the author and approved by the building principal.

Overview of the Project

The project consists of administering and scoring two tests given to ninth grade students. The first test given is the Woodcock-Johnson reading comprehension test. This test determines at what grade level the students comprehend written material. The second test is a mathematics problem-solving test consisting of a combination of multiple choice, short answer, and extended response questions. This test was developed using sample questions from the WASL test provided by the Commission on Student Learning (1999) (See Appendix B). After the tests were scored several statistical analysis instruments, from the book, Educational Research, were reviewed (Gay, 1996). The Chi-Square, *T*-test, Spearman rho, and Pearson *r* were the instruments used in an attempt to find the correlation coefficient. The final correlation of scores was conducted using the Pearson *r* correlation method. This method was used to correlate reading comprehension level and mathematic percentage scores. Correlations of these scores were conducted for each level of difficulty in mathematics questions, multiple choice, short answer, extended response, and total mathematics score. The Pearson *r* method is widely used in educational research because most of the information collected deal with interval or ratio scale data, such as standardized-tests (p. 303). The Pearson *r* was used because it was the most appropriate method for the data collected in this project.

Author Preparation

A special education teacher within the school district trained the author in the proper methods for administering the Woodcock-Johnson reading comprehension test. In addition the author observed and participated in five actual testing procedures with that special education teacher.

In preparation for the scoring of the mathematics portion of the project the author attended three seminars within the past year that dealt directly with the issue of scoring the WASL mathematics questions.

Testing Procedures

The Woodcock-Johnson test was conducted in a one-on-one situation between the author and the student. Each student scheduled a convenient time to meet with the author and be given the reading test. The procedure for administering this test is as follows: The proctor gives the student a question, and then based on the student's response another question is selected and given. This process continues until an accurate assessment of the student's reading comprehension level is obtained. After the student's reading grade level is determined he or she takes the problem-solving test.

The procedure for administering the sample WASL mathematics test was in several small groups after the regular school day had ended. The problem-solving test to be used in this project is a sample test given to many school districts to help prepare teachers and students for the types of test questions they will encounter. This sample test comes with scoring rubrics, answer keys, and anchor papers to be used to compare sample student answers with actual student answers (Commission on Student Learning, 1999) (See appendix A).

Results of the project

After the tests were corrected the students' reading scores and math scores were correlated using a Pearson *r* (r-value) or a scatter plot and linear regression analysis to see if any relationship existed between the students' reading comprehension level and their problem solving abilities. The correlation of reading comprehension level and mathematics scores was done at four different levels. The first correlation is between reading comprehension level and multiple choice mathematics questions (see Table 1/Chart 1). When data were analyzed an *r*-value of 0.7486053 was obtained. This *r*-value shows a moderate relationship between a student's reading grade level and his or her mathematics score. The second correlation is between reading comprehension level and a short answer mathematics question (see Table 2/Chart 2). When data were analyzed an *r*-value of 0.7660976 was obtained. This *r*-value also shows a moderate relationship between the two scores. The third correlation is between reading comprehension level and extended answer mathematics questions (see Table 3/Chart 3). When data were analyzed an *r*-value of 0.888125 was obtained. This *r*-value shows a stronger relationship between the two scores than the previous correlations. Finally, the fourth correlation was between the students reading comprehension level and his or her total score on the mathematics test (see Table 4/Chart 4). When data were analyzed an *r*-value of 0.923796 was obtained. This *r*-value shows a strong correlation between reading comprehension level and mathematics scores. The null hypothesis stated that reading comprehension level would not correlate with their mathematics score on a sample WASL mathematics test. The increase in Pearson *r*-values and the final Pearson *r*-value of 0.923796 is substantial enough to accept the null hypothesis.

Table 1: Reading grade level and Multiple Choice scores

| Student | Reading | Multiple choice | |
|---|---|---|---|
| | Grade level | 5 points possible | % |
| 1 | 9.3 | 5 | 100% |
| 2 | 9.8 | 5 | 100% |
| 3 | 11 | 5 | 100% |
| 4 | 9.6 | 5 | 100% |
| 5 | 8.8 | 4 | 80% |
| 6 | 7.9 | 3 | 60% |
| 7 | 9.7 | 5 | 100% |
| 8 | 9 | 4 | 80% |
| 9 | 9.3 | 5 | 100% |
| 10 | 9.1 | 4 | 80% |
| 11 | 8.3 | 4 | 80% |
| 12 | 8.5 | 4 | 80% |
| 13 | 11.3 | 5 | 100% |
| 14 | 12.4 | 5 | 100% |
| 15 | 10 | 5 | 100% |
| 16 | 10.6 | 5 | 100% |
| 17 | 9.4 | 4 | 80% |
| 18 | 9.9 | 5 | 100% |
| 19 | 9.1 | 4 | 80% |
| 20 | 8.1 | 3 | 60% |
| | r = | 0.748605398 | |

Chart 1: Reading grade level and Multiple-choice scores

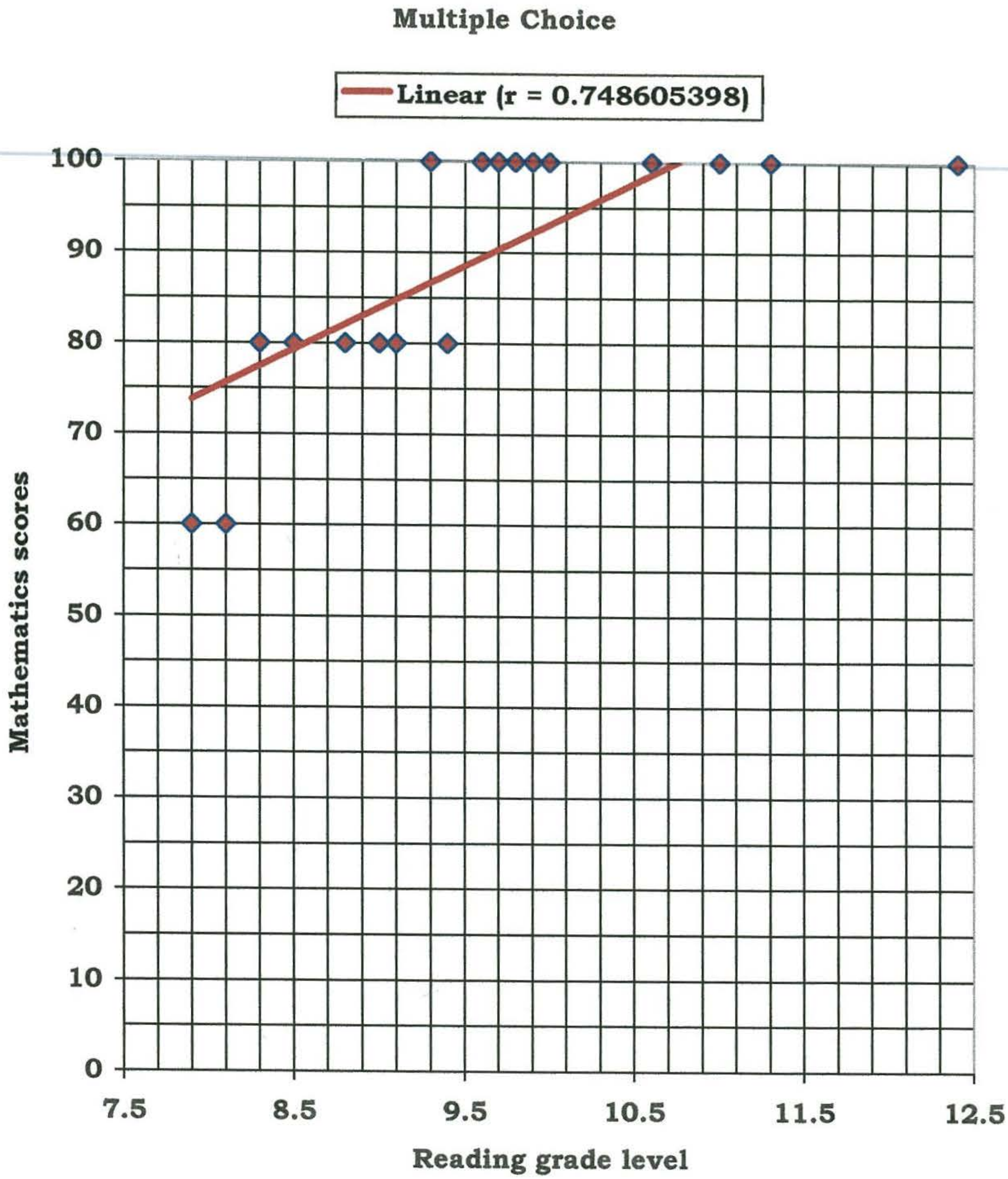


Table 2: Reading grade level and Short Answer scores

| Student | Reading | Short answer | |
|---|---|---|---|
| | Grade level | 3 points possible | % |
| 1 | 9.3 | 3 | 100% |
| 2 | 9.8 | 3 | 100% |
| 3 | 11 | 3 | 100% |
| 4 | 9.6 | 3 | 100% |
| 5 | 8.8 | 2 | 67% |
| 6 | 7.9 | 1 | 33% |
| 7 | 9.7 | 3 | 100% |
| 8 | 9 | 2 | 67% |
| 9 | 9.3 | 3 | 100% |
| 10 | 9.1 | 2 | 67% |
| 11 | 8.3 | 1 | 33% |
| 12 | 8.5 | 1 | 33% |
| 13 | 11.3 | 3 | 100% |
| 14 | 12.4 | 3 | 100% |
| 15 | 10 | 3 | 100% |
| 16 | 10.6 | 3 | 100% |
| 17 | 9.4 | 2 | 67% |
| 18 | 9.9 | 3 | 100% |
| 19 | 9.1 | 2 | 67% |
| 20 | 8.1 | 1 | 33% |
| | r = | 0.766097609 | |

Chart 2: Reading grade level and Short Answer scores

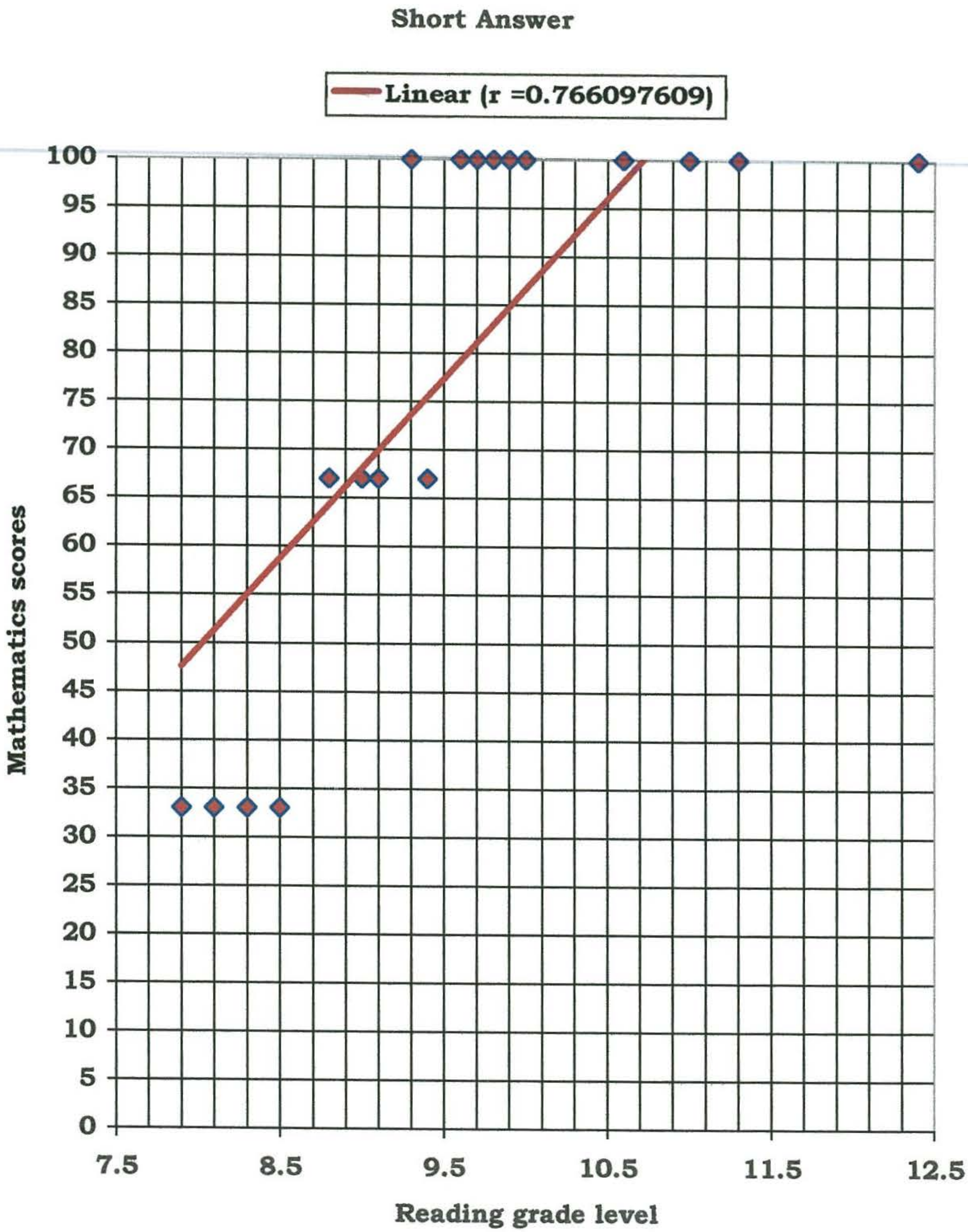


Table 3: Reading grade level and Extended response scores

| Student | Reading | Extended Response | |
|---|---|---|---|
| | Grade level | 4 points possible | % |
| 1 | 9.3 | 1 | 25% |
| 2 | 9.8 | 2 | 50% |
| 3 | 11 | 4 | 100% |
| 4 | 9.6 | 2 | 50% |
| 5 | 8.8 | 1 | 25% |
| 6 | 7.9 | 1 | 25% |
| 7 | 9.7 | 2 | 50% |
| 8 | 9 | 1 | 25% |
| 9 | 9.3 | 1 | 25% |
| 10 | 9.1 | 1 | 25% |
| 11 | 8.3 | 1 | 25% |
| 12 | 8.5 | 1 | 25% |
| 13 | 11.3 | 4 | 100% |
| 14 | 12.4 | 4 | 100% |
| 15 | 10 | 2 | 50% |
| 16 | 10.6 | 3 | 75% |
| 17 | 9.4 | 1 | 25% |
| 18 | 9.9 | 1 | 25% |
| 19 | 9.1 | 1 | 25% |
| 20 | 8.1 | 1 | 25% |
| | r = | 0.888125988 | |

Chart 3: Reading grade level and Extended response scores

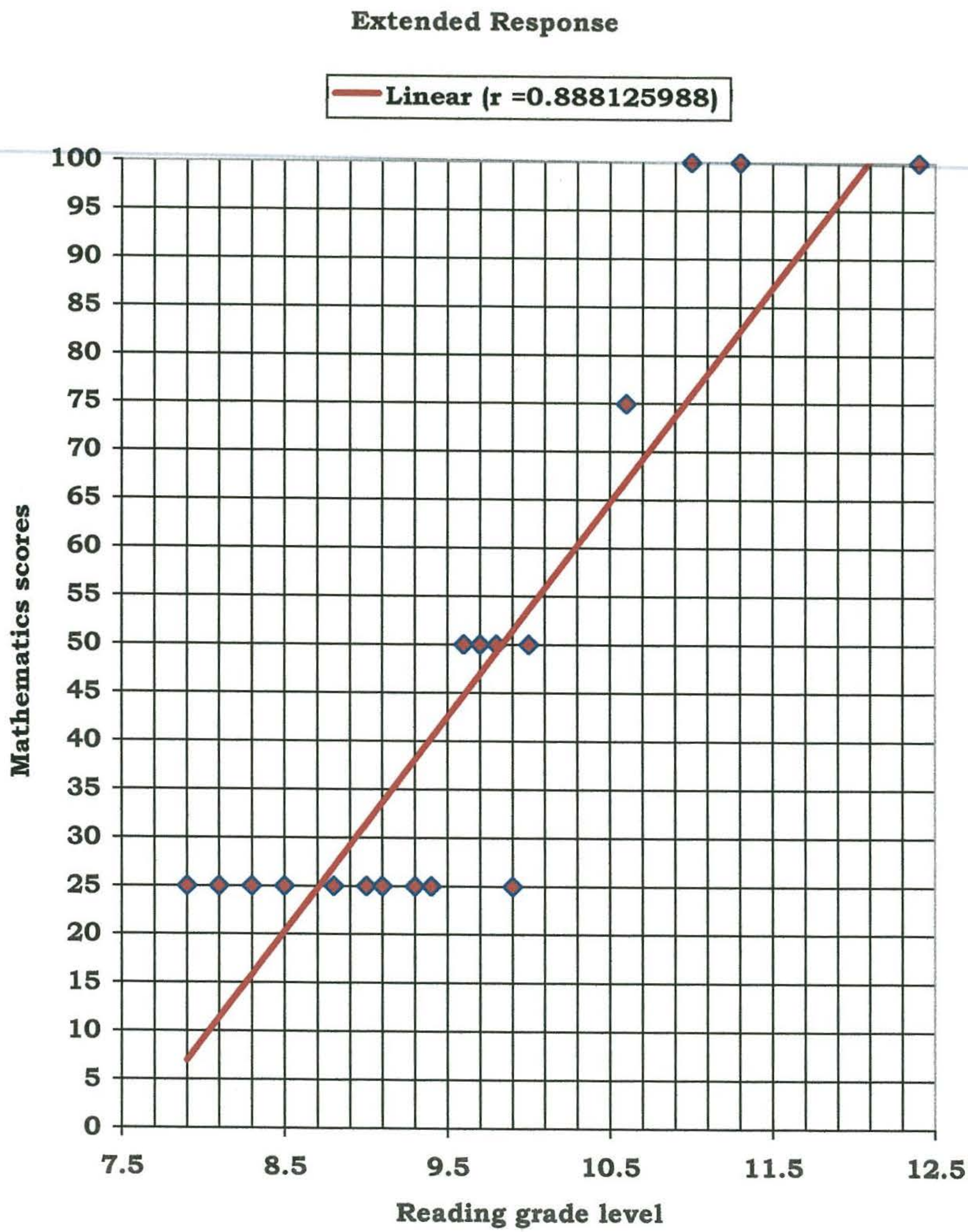
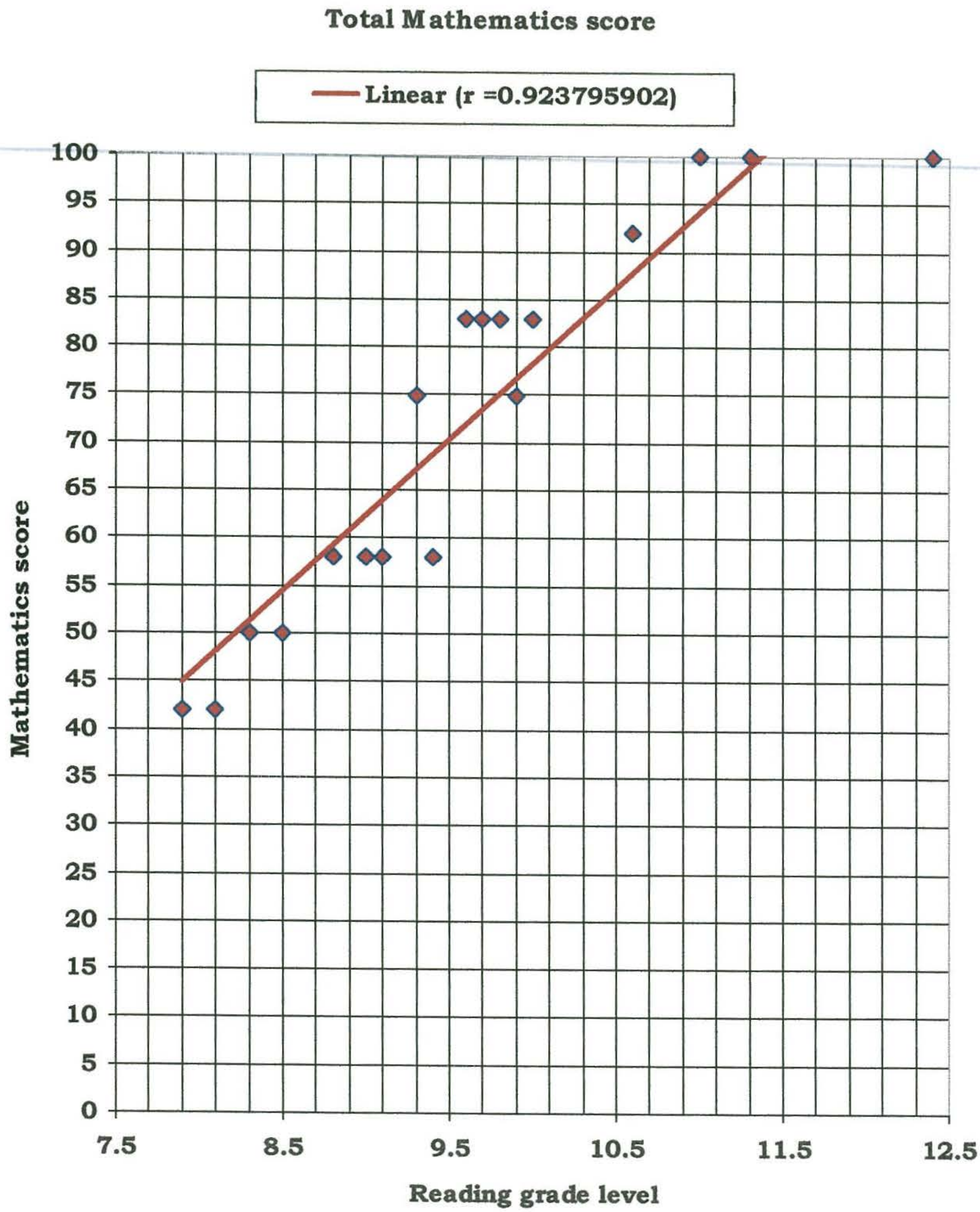


Table 4: Reading grade level and Total mathematics score

| Student | Reading | Total Score | |
|---|---|---|---|
| | Grade level | 12 points possible | % |
| 1 | 9.3 | 9 | 75% |
| 2 | 9.8 | 10 | 83% |
| 3 | 11 | 12 | 100% |
| 4 | 9.6 | 10 | 83% |
| 5 | 8.8 | 7 | 58% |
| 6 | 7.9 | 5 | 42% |
| 7 | 9.7 | 10 | 83% |
| 8 | 9 | 7 | 58% |
| 9 | 9.3 | 9 | 75% |
| 10 | 9.1 | 7 | 58% |
| 11 | 8.3 | 6 | 50% |
| 12 | 8.5 | 6 | 50% |
| 13 | 11.3 | 12 | 100% |
| 14 | 12.4 | 12 | 100% |
| 15 | 10 | 10 | 83% |
| 16 | 10.6 | 11 | 92% |
| 17 | 9.4 | 7 | 58% |
| 18 | 9.9 | 9 | 75% |
| 19 | 9.1 | 7 | 58% |
| 20 | 8.1 | 5 | 42% |
| | r = | 0.923795902 | |

Chart 4: Reading grade level and Total mathematics score



# CHAPTER FIVE

# SUMMARY, LIMITATIONS, CONCLUSIONS, AND RECOMMENDATIONS

## Summary

This project was conducted to examine the relationship between students' reading comprehension level and their ability to solve Washington Assessment of Student Learning (WASL) math test questions. This area of open-ended word problems on the WASL test is where students in the author's school district have the most difficulty. The reason the author chose to look specifically at mathematical open-ended problem solving is because the school district in which the author is employed is aligning the mathematics curriculum with the current Essential Academic Learning Requirements (EALRs). Within the author's district student math scores are low and many people want to know how to increase students' problem solving abilities so as to increase their state scores. This project explored whether there is a correlation between students' reading level and their ability to solve open ended word problems to see if there is a need to adjust the current mathematics curriculum to include a reading comprehension component. The project focused on the correlation between students' reading comprehension grade level and problem solving as defined by the EALRs recently implemented in Washington State.

An analysis between reading grade level and mathematics problem-solving scores was conducted at four different levels. The four levels of correlation were between reading grade level and scores of mathematics questions of varying complexity. In addition a correlation between reading comprehension grade level and total mathematics test score was completed. The mathematics test consisted of five multiple-choice questions, one short answer question, and one extended response question. An analysis of the results of the correlations indicates that a student's reading comprehension level does correlate with their ability to correctly answer problem-solving questions on the WASL test (See Appendix B).

Limitations of the Project

The limitations of the project indicate that further research is needed. Some of the limitations that discredit any firm conclusions are as follows. The size of the project was limited to only twenty students. Although these subjects were randomly chosen, a larger sample size would have increased the validity of the results. Also, only one grade level of students was chosen and from only one school district. Another limitation would be the size of the mathematics test, which only contained five multiple-choice questions, one short answer question and one extended response question. The total possible score on this mathematics test was twelve. A limited number of mathematic questions results in an intensified variance between student percentage scores obtained. In addition the reading grade level scores could also be inaccurate. This possibility exists because the author is not certified to administer and score this test. Finally, the last possible limitation could be researcher bias. Because the researcher is in contact with most of the subjects on a daily basis and has formed a personal relationship, bias in scoring the short answer and extended response questions might be possible. Also, bias on the part of the researcher may exist because the researcher conducted the study personally with little outside help.

## Conclusions

The results of the project show that there is clearly a relationship between reading comprehension level and the ability to correctly answer sample WASL mathematics problem-solving questions. Correlations of these scores were conducted at each level of difficulty of mathematics questions. The difficulty levels were multiple-choice questions, a short answer question, and an extended response question. In addition a correlation of reading comprehension level and total mathematics score was conducted. An analysis of the Pearson *r*–values shows an increase from 0.748605398 for multiple choice questions to 0.923795902 for total mathematics score.

The Pearson *r-value*s indicate the rejection of the null hypothesis. The limitations of the project, however, preclude drawing firm conclusions about the correlation of student reading comprehension level and his or her ability to correctly answer mathematic problem-solving questions. Although the results are positive, limitations of this project indicate the need for further research in this area.

## Recommendations

Since the data clearly show a correlation between reading comprehension grade level and mathematics test scores, but the limitations of the project detract from drawing any firm conclusions, further research in this area is indicated. The author will recommend to his district superintendent that a continuation of this study be done on a larger scale.

This new study would include testing a random sample of fifty students from each of the fourth, seventh, and tenth grades in mathematics and reading comprehension level. The subjects would be tested for their reading comprehension level in the winter semester, by people certified too administer and score the Woodcock-Johnson test. The subjects would then take the WASL test in the spring. The scores would be correlated using the Pearson $r$ method in the fall when the school district receives the WASL results. The reading level of each student should be correlated with each section of the WASL test, multiple choice, short answer, and extended response. Data gathered from this study could be used to make more substantiated recommendations to the current mathematics curriculum in the author's district. The one drawback to this type of study is obtaining WASL mathematics test score breakdowns for each student would be almost impossible to accomplish.

Because the individual student scores of the WASL test are so difficult to obtain a study that would correlate the overall WASL reading and mathematics test scores with each other might be more feasible. These scores are provided to all school districts in the fall of every school year. The data delivered are a description of how each student scored on each section of the WASL test. These descriptions are only overall scores of each section and not detailed analysis of how students scored on individual sections. This data would be interesting to review to see if scoring well on the reading section of the test correlates with scoring well on the mathematics section of the test.

In addition to correlating reading comprehension level scores with WASL mathematics scores a recommendation will be made to study the correlation of writing competency scores and WASL mathematic scores. In this project some of the students may have discovered the correct answer to the short answer or extended response question, but lacked the skills to communicate their thoughts in written form. A detailed study could prove that a combination of reading and writing instruction would improve WASL mathematics scores.

Finally, a recommendation to increase the amount of reading of mathematics material in the classroom will be given to the author's school district staff. Students should be expected to read and respond to articles, word problems, and other written material using mathematical terminology.

Adjustments to the current district curriculum would be as follows. Students in the lower grades, kindergarten through second grade, will be required to maintain a vocabulary journal in addition to their daily mathematics assignments. This journal will include new terms that the students encounter and need to define. In grade levels three through eight a journal should also be kept and these new terms should be discussed and used in response to simple word problems that the students address in their daily work. Adjustments to the high school curriculum should include: A journal of new terms, written responses to articles on mathematics, and an increased number of word problems in their daily work in addition to the standard drill and practice lessons currently used. If the results of this project are any indication of what our students lack in the area of mathematics, a different approach to the way we teach mathematics needs to be implemented if our students are to be successful in this area.

REFERENCES


Andrews, P. (1999). A new look at secondary teachers' conceptions of mathematics and its teaching. British Educational Research Journal. 25, 203-223.

Battista, M. (1999). The mathematical miseducation of America's youth. Phi Delta Kappan, 80, 424-433.

Bernardo, A. (1999). Overcoming obstacles in understanding and solving word problems in mathematics. Educational Psychology, 19, 149-163.

Burns, M. (1997). Finding multiple ways to salve a problem. Instructor, 107, 72-73.

Busey, J. (1999). Personal interview.

Chinnappan, M., Lawson, M. (1996). Student difficulties with accessing and using mathematical knowledge. School Science and Mathematics, 96, 140-156.

Commission on Student Learning. (1997). Essential academic learning requirements and components. Olympia, WA: Office of Superintendent of Public Instruction.

Commission on Student Learning. (1999). Washington assessment of student learning example test, grade 10. Olympia, WA: Office of Superintendent of Public Instruction.

Fuentes, P. (1998). Reading comprehension in mathematics. The Clearing House, 72, 81-88.

Gay, L. (1996). Educational research: Competencies for analysis and application. Upper Saddle River, NJ: Prentice Hall Inc.

Krussel, L. (1998). Teaching the language of mathematics. The Mathematics Teacher, 91, 436-441.

Manning, M. (1999). Building reading skills in math. Teaching Pre K-8. 29, 85-86.

McIntosh, M. E. (1997). Guide students to better comprehension of word problems. The Clearing House, 71, 26-32.

Mikusa, M. G. (1998). Problem solving is more than solving problems. Mathematics Teaching in the Middle School, 4, 20-25.

National Council of Teachers of Mathematics. (1989). Curriculum and evaluations standards for mathematics. Reston, VA: Author.

Ostler, E. (1997). The effect of learning mathematical reading strategies on secondary students'. The Clearing House, 71, 37-40.

Pugalee, D. (1997). Connecting writing to the mathematics curriculum. The Mathematics Teacher, 90, 308-310.

Quinn, C. (1997). Problem solving does not have to be a problem. The Mathematics Teacher, 90, 536-542.

Wakefield, A. P. (1997). Supporting math thinking. Phi Delta Kappan, 79, 233-236.

Woodcock, R., (1989). Woodcock-Johnson Psycho-Educational battery (Rev. ed.). Riverside Publishing.

# APPENDIX A

**ZILLAH HIGH SCHOOL**
**PERMISSION FORM**

Dear parents/guardians,

My name is Darren Cooper and I am one of the mathematics teachers at Zillah High School. I am currently enrolled in a masters degree program through Central Washington University. One of the requirements of this program is to complete a master's project. The project I have undertaken is a study that will compare ninth grade student's reading abilities and their problem solving abilities. The reason I have chosen to do this study is because of the new state test that all tenth grade students are required to take. The scores in our district are some of the highest in the area. Even so, mathematics scores are lower than we would like them to be. My goal is to see if a student's reading ability has any correlation with their ability to correctly answer mathematics questions. In order to find out this information I need your permission to test your child's reading comprehension level and mathematics abilities. Your child has been selected randomly from a list of ninth grade students.

I will administer the reading test, in a one-on-one situation. It should take about thirty minutes. The problem-solving test will be given in several small groups and should only take approximately forty-five minutes.

Both of these tests will be given after school. All of the test scores will be kept confidential. The scores on these tests will not affect their current grades in any mathematics class. These scores are for the sole purpose of discovering if reading comprehension level has any effect on correctly answering mathematics questions.

I hope you will give your consent for your child to participate in this project.

Sincerely,

Darren Cooper
Zillah High School
Mathematics Department

Parent/Guardian signature______________________________ Date____________

Phone # (     ) ______________________________________

Student signature______________________________________ Date____________

# APPENDIX B

## Mathematics

**1** Three of the four statements below are equivalent. Which of these statements is **not** equivalent to the other three?

- ○ **A.** $\frac{A}{B} = \frac{C}{D}$
- ○ **B.** $\frac{B}{C} = \frac{D}{A}$
- ○ **C.** $\frac{D}{B} = \frac{C}{A}$
- ○ **D.** $\frac{B}{A} = \frac{D}{C}$

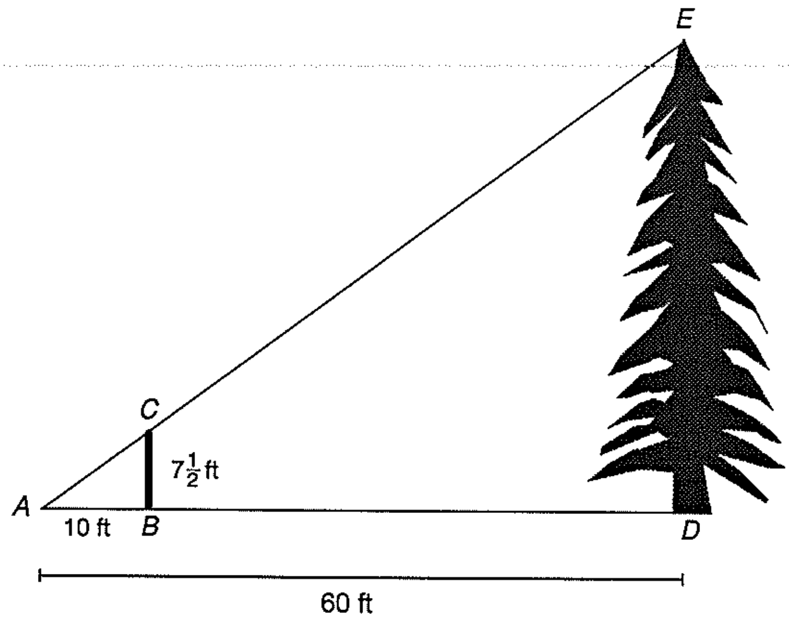
**2** Naomi is a travel agent. She receives a commission of 5% for each ticket she sells. How much would her commission be from the sale of 6 airline tickets for $250 each?

- ○ **A.** $150.00
- ○ **B.** $125.00
- ○ **C.** $75.00
- ○ **D.** $12.50



Go On ►

3 Jacinda wants to use the idea of similar triangles to find the height of the pine tree in her backyard. She starts at the base of the pine tree (point $D$ in the diagram below) and measures the distance to the tip of the tree's shadow (point $A$). At point $B$, Jacinda places a $7\frac{1}{2}$-foot pole, which casts a 10-foot shadow in the same light.



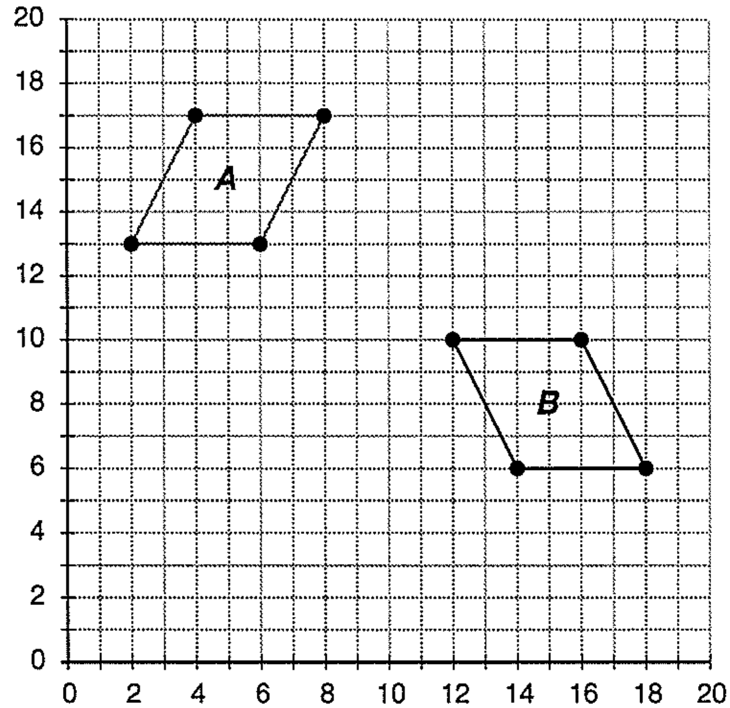

What relationship should Jacinda use to find the height of the pine tree?

- ○ **A.** $\overline{AB}$ is to $\overline{BC}$ as $\overline{BD}$ is to $\overline{DE}$.
- ○ **B.** $\overline{AB}$ is to $\overline{AC}$ as $\overline{AD}$ is to $\overline{CE}$.
- ○ **C.** $\overline{BC}$ is to $\overline{DE}$ as $\overline{AB}$ is to $\overline{BD}$.
- ○ **D.** $\overline{BC}$ is to $\overline{AB}$ as $\overline{DE}$ is to $\overline{AD}$.

## Mathematics

**4** A friend calls you for help with the given transformation. **Describe in detail** how you would produce figure B, from figure A, using only verbal clues. The following terms may be useful in your explanation.

*translate* or *slide*
*reflect* or *flip*
*rotate* or *turn*

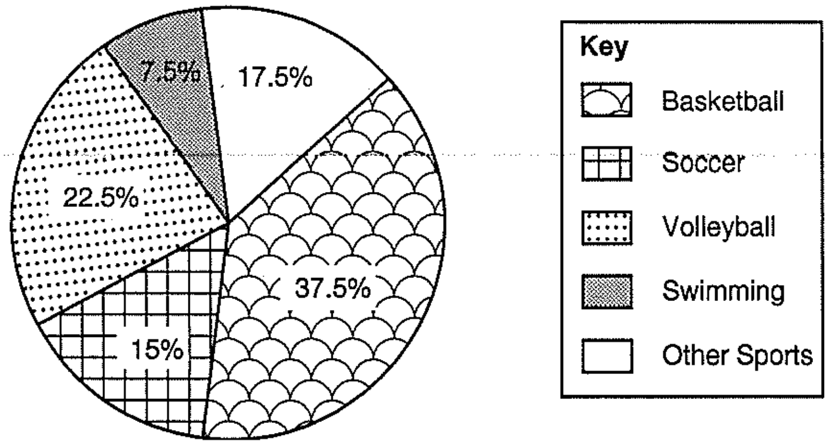





Go On

**Use the graph below to answer questions 5 and 6.**

**Favorite Sports of a Sample of 10th Grade Students at Lincoln High School**




**5** The students in Mr. Chan's class surveyed an additional 120 Lincoln High School tenth-graders. How many of these students would you expect to choose volleyball as their favorite sport?

- ○ **A.** 19
- ○ **B.** 23
- ○ **C.** 27
- ○ **D.** 45

**6** Which conclusion can be drawn from the graph above?

- ○ **A.** The swim team has fewer members than the soccer team.
- ○ **B.** More tenth-grade students chose volleyball than soccer.
- ○ **C.** Basketball is the favorite sport among all students at Lincoln High School.
- ○ **D.** Swimming is the least favorite sport among tenth-grade students at Lincoln High School

## Mathematics

7 Production workers at a local business are dissatisfied with their pay. The owner of the business doesn't want to increase the workers' pay. Both sides place the following ads, (which are true), in the local newspaper to gain public support for their position.

**XYZ Corporation Underpays Production Workers**

The records show that 80% of the employees of XYZ earn the same low yearly salary. These are all production workers. Together, they earn only 50% of the total XYZ payroll.

Meanwhile, owner Keene earns 10 times as much as each of these workers.

It is easy to see that the production workers are underpaid. Thanks for your support of our upcoming action.

**Highest Average Salary in Entire County**

Wouldn't you like to earn $16,000 per year? That's the average salary of all 50 of us who work at XYZ Corp.— myself included. And it's tops in the county for production workers.

I make only 5% more than my best-paid production worker. And my salary accounts for only 12.5% of our total payroll.

Signed,
J.M. Keene
(owner XYZ)

Since both ads are truthful, analyze the information in these two ads, and explain four logical interpretations or conclusions you can make about the salaries from the combined information. Clearly show how you arrived at each statement.

Additional work space