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THE RELATIONSHIP BETWEEN READING FLUENCY AND MATHEMATICAL WORD PROBLEM SOLVING: AN EXPLORATORY STUDY

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ABSTRACT

The present study examined the relationship between Oral Reading Fluency (ORF) scores and mathematics problem solving scores. The reading fluency scores were obtained from the Dynamic Indicator of Basic Early Literacy (DIBELS) assessment. The mathematics problem solving scores were obtained from the Indiana State Test of Education Progress Plus (ISTEP+) assessment. In addition, error patterns found in mathematics problem solving on ISTEP+ and Acuity Diagnostic Tests were analyzed.

The purpose of the quantitative study was to determine if DIBELS ORF scores were correlated with mathematics problem solving ISTEP+ scores. A linear regression was conducted to determine the significance of the correlation. The purpose of the qualitative study was to determine error patterns found on the Mathematics Problem Solving portion of the ISTEP+ test and the Acuity Mathematics Diagnostic test. For both studies, the data were evaluated for the whole group, male group, and female group. For the qualitative analysis, data were also examined based on DIBELS oral reading fluency level. A total of 121 students in Grades 3, 4 and 5 were used for the study. The students attended an inner city school in the midwestern portion of Indiana. Several ethnic groups were represented, including Caucasian, Hispanic, African American, and multiracial. The majority was from high poverty level homes and qualified for either free or reduced lunch services.

The results of the quantitative portion of this study indicated that for the whole group a moderately significant positive correlation existed between DIBELS ORF scores and ISTEP+

mathematical problem solving scores. The data for the male group had a low significant positive correlation and a strong significant positive correlation for the Female group. DIBELS ORF scores were a significant predictor of ISTEP+ mathematics scores for all three groups.

The results of the qualitative study indicated that student reading fluency level impacted mathematics problem solving ability. Consistently, those students reading at the benchmark level outperformed those students reading at the strategic and intensive levels. From both the ISTEP+ and Acuity Diagnostic assessment, several error patterns were determined. These error patterns included the number of words per question, mathematical vocabulary and terminology, unfamiliar scenarios, use of ethnic or uncommon names, nonstandard words for computation, and multiple meanings within the questions. The errors were prevalent for both genders and most common at the intensive reading level.

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CHAPTER 1

THEORETICAL CONTEXT

Educational reform is on the agenda of not only those involved in education firsthand but also government leaders and business leaders alike. The quality of education students are receiving is being questioned and examined. The importance of students being able to contribute to the workforce is dire. "Mathematical competence accounts for variance in employment, income, and work productivity," (Rivera-Batiz as cited in Fuchs et al., 1990, p. 561). Lubienski (2007) remarked that achievement in mathematics was particularly important. Her reasoning for this statement was that mathematical competence served as a "gatekeeper to high status occupations" (Lubienski, 2007, p. 55). In keeping with this statement, in regards to reading, Rangappa (1993) expressed the importance of reading "because it illuminates human experiences and provides an impetus to think, understand, interpret, and reason out" (p. 25). These statements by those in educational research highlight the importance of students being educated well and graduating from school with a foundation of skills in both reading and mathematics that are at the mastery level.

The achievement of students in the United States in the area of mathematical problem solving has been examined. The National Assessment of Educational Progress (NAEP, 2005) reported that in 2005 64% of fourth graders failed to meet proficient levels in mathematics. On the assessments used to gain data for the Nation's Report Card evaluation, the questions are divided into low, medium, and high complexity questions. The test covers five content areas in math, including number properties and operations, measurement, geometry, problem solving, algebra, statistics, data analysis, and probability. The test given to fourth grade students in 2005 contained approximately 34 items covering the preceding content. Of these items, one third were labeled as problem solving/constructed response type problems. Several questions under other content areas could be considered a problem solving format (NAEP, 2005). Although 64% is a startling national failure rate, the statistics when comparing American students to students around the world are even more alarming. The National Council of Teachers of Mathematics published a report comparing fifth grade students from the United States, China, and Japan (as cited in Roti, Trahey, & Zerafa, 2000). The American students had the lowest mean scores on word problems. Even more distressing, 100 of the lowest scores out of 720 students were American fifth graders. Furthermore, only one American was found in the top 100 highest scoring students (Roti et al., 2000). A similar study from the NAEP (2005) found that on constructed response, word problem questions the average number of fourth graders producing satisfactory responses was only 16%. The National Research Council of the National Academy of Sciences reported there was a lack of research in the area of mathematical ability specifically how it relates to other areas such as reading (Hart, Petrill, Thompson, & Plomin, 2009). Establishing a connection between reading and mathematical proficiency was a hallmark in the research.

Need for the Study

Much attention has been paid to how oral reading fluency can be used to predict student achievement on comprehension assessments. Research has also been completed on the relationship between students with both reading and mathematical learning disabilities.

However, there is little research that has been completed showing how a student's performance on assessments of oral reading fluency relates is predictive or how it varies from the student's performance on a standardized constructed response assessment (Rasanen & Ahonen, 1995). A study completed by Rasanen and Ahonen (1995) shows the relationship between oral reading fluency and mathematics fact retrieval; however, more information relating to oral reading fluency and word problem solving ability is needed. There is strong evidence supporting the need of such a study (Vilenius-Tuohimaa, Aunola, & Nurmi, 2008).

In order to provide interventions and targeted instruction to students who are unable to consistently solve word problems correctly, the underlying reason for their deficit needs to be determined. Researchers in the field of special education are interested in this research as well, due to the fact that mathematical learning disabilities could be better categorized if the specific cause of learning difficulty was better understood. Students with mathematical learning disabilities could be more specifically identified as those with basic fact and computation difficulties verses those with problem solving difficulties due to lack of reading fluency (Hale, Fiorello, Bertin, & Sherman, 2003; Rasanen & Ahonen, 1995).

Because standardized testing results play a large role in educational decision making, it is imperative that the data derived from these test be used to increase student success. Much attention has been given to mathematics at the national level through the work of both the National Mathematical Advisory Panel and the National Council of Teachers of Mathematics. Keller-Margulis, Shapiro, and Hintze (2008) stated that curriculum-based measures can be used to determine the likelihood of success or failure on achievement tests. The Dynamic Indicator of Basic Early Literacy Skills (DIBELS) is a set of tests designed to assess student achievement in literacy (University of Oregon, n.d.a). Since DIBELS ORF is considered a curriculum-based measure, it is reasonable to use these data for prediction. This score could be taken one step further and used not only to predict reading success of failure but also predict success or failure on constructed response portions of mathematical subtests which include word problems

Statement of Problem

Although the statistics in mathematical proficiency or lack thereof are concerning, those related to reading fluency are also worrying. The NAEP (2005) reported that 45% of all fourth graders read below the minimally accepted levels. They further reported that only 13% of fourth graders read at the highest fluency level (Fountas & Pinnell, 1996). Rasinski and Padak (2004) stated, "Reading fluency is a significant obstacle to proficient reading for elementary students" (p. 110). With these low figures, there possibly comes a negative effect on other subject areas. In the area of mathematics, the goal of most questions is to solve a problem. Questions are often presented using text; therefore, students must be able to first and foremost read the text and read it fluently before beginning to use math skills to solve the problem. If students are struggling when reading the text, their ability to then utilize this text to solve the problem may be compromised. The areas of reading and mathematics are the primary focus and foundation of learning in elementary schools. Achievement in these areas is needed for success in future academic endeavors and in the majority of careers. Establishing a relationship between students' reading fluency ability and how that impacts their ability to solve mathematics problems is needed. A study of how all levels of reading fluency does affect other areas of study, specifically mathematics, is warranted.

An array of research on educational topics can be found today. The literature and knowledge base associated with student reading ability and reading skills is among the largest (Rasinski & Padak, 2001). Reading ability is related to fluency and reading level. Reading skills encompass all the major components of reading which include: phonemic awareness, phonics, fluency, vocabulary, and comprehension (University of Oregon, n.d.a). On the other hand, literature associated with mathematical ability is not as widely published (Hart et al., 2009). Moreover, relatively little literature and knowledge has been investigated on the relationship between reading and mathematics (Gersten, Jordan, & Flojo, 2005). That being said, in an era of poor performance by students in mathematics, it is crucial that the relationship be studied and foundations for the relationship be established. With employers looking for employees who are competent in the fundamental areas of reading and mathematics, establishing a relationship between the two areas would be worthwhile. Even more specifically, employers are looking for people who can analyze and solve problems. These are the very skills needed to solve constructed response type problems (Covey, 2008). Understanding how the two relate and if improvement in fluency could improve students' ability to problem solve in mathematics could help shape the focus of educators. Improvement in mathematical problem solving is two-fold. Competence in this area is needed when students are in school and it is still needed when students are in the workforce (Lubienski, 2007).

A multitude of decisions are made in the legislature based on student performance indicated by outcomes of standardized tests. In accordance with the No Child Left Behind Act of 2001, states will establish annual reading and mathematics assessments. The progress on these assessments will be reported and decisions for schools will be made in relation to student achievement. The most influential of these decisions on education is that of funding. Allocation of monies is based in large part on student performance on a single assessment. Although funds are provided to schools that do not perform well on the assessments, schools that make progress are honored with awards from the *No Child Left Behind* Fund and the *Achievement in Education* state fund (U.S. Department of Education, n.d.). Under this act, schools may also receive funds to improve technology, support character education, increase safety within the school, and provide professional development for teacher (U.S. Department of Education, n.d.). This type of legislation supports that more funding for schools promotes better education which in turn equals higher student achievement. With stakes this high, the importance of student achievement is profound. Educators are already feeling a sense of urgency in preparing students and teaching them mastery of required skills, but mandates push it to a *do or die* level.

With this sense of urgency comes a responsibility of educators to be aware of students' performance and areas of need. Teachers must understand how all facets of cognition impact each area of learning. Data is driving instruction in classrooms all over the United States. Often, the amount of data a teacher has to utilize is overwhelming. Teachers use observations, anecdotal records, and formal and informal assessments to make decisions about how to best educate students and which skills to emphasize. Data can be found for students' reading level, fluency level, performance on state standards, and performance on national standards. With the large amount of data available, teachers can determine specific needs for individual students.

However, a component of data analysis that may be missing is relationships between data sources. It would be valuable for teachers to know if one score can be predictive of another score within and between subject areas. Since the passing of the No Child Left Behind Act in 2001, the significance of developing a student's reading skills, specifically fluency, has been in the foreground of discussions (Kim, Petscher, Schatschneider, & Foorman, 2010). There has been little if no discussion of the bearing of reading fluency on other educational domains. Educators must be able to make predictions regarding student learning and understanding. They must also have a strong understanding of how student ability will impact both achievement and performance on standardized tests. There is much value in knowing how to analyze data to make decisions regarding how to proceed with lessons and determining teaching objectives. This is not just true for each subject area independently. An understanding of the correlations between achievement in one subject area and the impact that achievement or lack of achievement has on other subject areas is important. Decisions in how to proceed can be better made if research supports the correlations and relationships between subject areas. For example, if a student is struggling with solving mathematical word problems, the teacher must be able to analyze the error the student is making to be able to then differentiate instruction so as to lead to student success. If a relationship between fluency and math problem solving is established, then the teacher would not only analyze the math errors, but also consider the student's level of reading fluency. Then a more worthwhile decision can be made on the starting point and subject area in which to begin remediation for the student in order to reach the ultimate goal of success with mathematical word problems. Therefore in this example, if the student does have a low level of fluency and there is a relationship between fluency and mathematical problem solving, the teacher will build the fluency skills in order to increase the student's mathematical problem solving skills. For schools that are consistently low performing in the area of mathematics constructed response problem solving, knowing this relationship would be beneficial in order to make adaptations and changes to teaching practices. A greater effort in improving fluency levels could lead to improvement on the mathematics portion of assessments. Teachers frequently integrate subject areas when teaching and research supporting the relationships between subjects could lead to improvement in both teaching and learning.

Teachers must be able to effectively analyze and use data from assessment sources in order to prepare students. Analysis of the data is pertinent to increasing student achievement in all areas. The data need to be considered in ways beyond just how a student ranks among his or her peers. Teachers need to know how scores in one area correlate with scores in other areas. They need to be able to use these scores to make predictions about other scores. A correlation has been made between oral reading fluency scores and scores on criterion-based measures. The correlation has been verified in Grades 3 and higher (Beringer et al., 2010; Stage & Jacobsen, 2001). This is in keeping with the framework of the No Child Left Behind Act (Baker, Smolkowski, Katz, Fien,Seeley, Kame'enui et al. 2008). Now the next step is an understanding of how oral reading fluency correlates with all subject areas. An awareness of the correlational and predictive qualities of assessments will lead to better understanding of student ability and performance. Lubienski (2007) and Rangappa (1993) addressed how mathematical ability and literacy, respectively, impact success in the job market. Essentially, educators are preparing students to leave the classroom and enter the job market. For these young adults, their competence in mathematics and literacy will be of great benefit in their areas of work and appreciated and applauded by employers. In order for students to achieve at their maximum potential, an understanding of relationships between the key area of mathematics and literacy is founded.

This study looked specifically at the relationship between oral reading fluency and mathematical problem solving ability. Knowing how one impacts the other is essential to a teacher’s ability to provide lessons that improve student learning in both fluency and mathematics. If the relationship can be established, educators can focus more precisely on areas of need for students in order to improve student learning and standardized test scores and life chances.

Along with a quantitative study of oral reading fluency and constructed response data in mathematics, a qualitative study was carried out. This portion of the study looked specifically at the errors on mathematical constructed response tests to determine common themes related to reading errors. An analysis of the types of questions students are missing was explored to determine if there is a pattern in errors related to the amount of reading required per question. Also the implications of mathematics vocabulary were examined. The data source for this analysis came from two standardized tests given to the participants of the study. The ISTEP+ tests (Indiana Department of Education (n.d.) and Acuity tests (CTB/McGraw Hill, n.d.) were examined to determine if students are frequently missing questions that contain specific mathematics vocabulary words. A further investigation discerned if students are incorrectly answering these questions due to lack of fluency and comprehension with specific vocabulary words. Findings of this study could guide reading specialists in working more closely with classroom teachers and teachers of mathematics specifically to improve word problem solving ability. This study may uncover specific causes of reading errors in mathematics problems that will inform classroom teachers.

The specific problem for this study was to determine the extent to which scores on an oral reading fluency assessment can predict the scores on constructed response mathematical assessments. The study also looked for connections between fluency and mathematical achievement and errors found on constructed response problem solving. Additional problems investigated were approached using a qualitative study. This portion of the research examined patterns in reading errors on constructed response mathematics assessments.

Purpose of the Study

The purpose of the study was to investigate the predictability and relationships between oral reading fluency and mathematical problem solving ability. After a relationship between the two variables is established, teachers can better use this data to plan instruction. By establishing predictability, teachers can use this information to differentiate instruction to meet specific student needs. The error patterns found in the qualitative portion of the study may assist teachers in understanding the cognitive process that emerges when students solve problems. From these error patterns teachers can alter reading fluency and mathematical instruction to accommodate solutions to common errors found in problem solving before the errors are made. Effective instructional strategies may lead not only to increased standardized test scores but also to a greater ability in mathematical problem solving. Eventually, this may impact life chances for students in terms of success in higher education and obtainment of a quality career. Both institutes of higher learning and employers are seeking students who are able to utilize skills such as reading fluency and mathematical problem solving.

Research Questions

Research Question 1. Among third, fourth, and fifth grade students, is there a significant relationship between their oral reading fluency scores and mathematics constructed response scores?

Research Question 2. Is there a significant relationship between oral reading fluency scores and mathematics constructed response scores stronger dependent on gender (using descriptive statistics without a priori cutoff for meaningful difference)?

Research Question 3. Among third, fourth, and fifth grade students, are DIBELS ORF scores and ISTEP+ constructed response scores correlated?

Research Question 4. Is the correlation between DIBELS ORF scores and ISTEP+ constructed response scores stronger for one gender (using descriptive statistics without a priori cutoff for meaningful difference)?

Research Question 5. Among third, fourth, and fifth grade students, what common error patterns related to reading fluency can be detected on ISTEP+ mathematical constructed response and Acuity Diagnostic Assessment?

Research Question 6. What differences exist between genders in common error patterns related to reading fluency on the ISTEP+ mathematical constructed response and Acuity Diagnostic Assessment?

Research Question 7. Among third, fourth, and fifth grade students, what errors in mathematical problem solving ability are related to mathematical vocabulary knowledge?

Research Question 8. What differences exist between genders in errors in mathematical problem solving ability related to mathematical vocabulary knowledge?

Research Question 9. Among third, fourth, and fifth grade students, what errors in mathematical problem solving ability are related to the amount of reading of text in the problem?

Research Question 10. What differences exist between genders in errors in mathematical problem solving ability related to the amount of reading of the text in the problem?

Null Hypotheses

$H_0$1: There is no predictability between oral reading fluency scores and mathematical problem solving scores.

$H_0$2: There is no predictability between oral reading fluency scores and mathematical problem solving scores for female students.

$H_0$3: There is no predictability between oral reading fluency scores and mathematical problem solving scores for male students.

$H_0$4: There is no correlation between oral reading fluency scores and mathematical problem solving scores.

$H_0$5: There is no correlation between oral reading fluency scores and mathematical problem solving scores for female students.

$H_0$6: There is no correlation between oral reading fluency scores and mathematical problem solving scores for male students.

Definition of Terms

Acuity is a comprehensive test developed by CTB/McGraw Hill (n.d.) to assess student proficiency on state academic standards.

Benchmark reading level is the minimum level of performance on a DIBELS test to be considered on track in oral reading fluency (University of Oregon, n.d.a).

Dynamic Indicator of Early Literacy Skills (DIBELS) is a set of procedures and measures for assessing the acquisition of early literacy skills from kindergarten through sixth grade (University of Oregon, n.d.b).

Curriculum based measures (CBM) is a set of procedures for measuring academic proficiency in basic skill areas including reading, spelling, written expression, and mathematics (Baker et al., 2008).

Intensive reading level is the minimum level of performance on a DIBELS test to be considered at risk for deficits in oral reading fluency (University of Oregon, n.d.a).

Indiana State Test of Educational Progress (ISTEP+) measures student achievement in the subject areas of English/language arts, mathematics, science, and social studies. In particular, ISTEP+ reports student achievement levels according to the Indiana Academic Standards that were adopted in November 2000 by the Indiana State Board of Education. A constructed response assessment and a multiple choice assessment are used to measure these standards; they are required components of the ISTEP+ program (Indiana Department of Education, n.d.).

Mathematical constructed response is a this type of question that requires students to apply mathematical knowledge to a given situation in order to solve the problem. Often these are multiple step problems requiring students to show their work, provide and answer, and then explain how they reached their answer, or provide additional written information related to the question (Indiana Department of Education, n.d.).

Mathematical problem solving refers to skills including the ability to recognize and define problems, *invent* and *implement* solutions, and track and evaluate results (Vilenius-Tuohimaa et al., 2008).

Oral Reading Fluency (ORF) is a standardized, individually administered test of accuracy and fluency with connected text. The passages are calibrated for the goal level of reading for each grade level. Student performance is measured by having students read a passage aloud for one minute. The number of correct words per minute from the passage is the ORF score (University of Oregon, n.d.b).

Strategic reading level is the minimum level of performance on a DIBELS test to be considered to have some risk for deficits in oral reading fluency (University of Oregon, n.d.b).

Word problems are any mathematical problems in which background information on the problem is presented as text rather than numbers. The problem often involves a *narrative* of some sort, and students must use this to construct number sentences and make calculations.

These types of problems are also referred to as *story problems* and may vary in the amount of language use (Fuchs et al., 2009)

Limitations

Limitations are found in this study. All of the students included in the study were third, fourth, and fifth grade students from one school in Vigo County, Indiana. The extent to which these students represent all third, fourth, and fifth grade students in the United States limits the study. The study was limited to the general education population. Those students identified as having specific learning disabilities, mild disabilities, or communication disorders were eliminated to avoid a skew of the data. The data sources were from three specific testing windows during the 2009-2010 school year. The data were not gathered over a lengthy period of time. Each data source was from the same population; therefore, students who were not enrolled during one of the testing windows were not included in the study due to lack of data.

Assumptions

The data were from students enrolled in Grades 3, 4, and 5 of an elementary school during the 2009-2010 school year. It is assumed the scores used were representative of the students assessed. It is further assumed the data sources provided an accurate representation of students' skills and knowledge base in all general and specific areas assessed. It is also assumed that DIBELS ORF, ISTEP+, and Acuity are found to be valid and reliable tests. A final assumption was that there was no difference between oral reading versus silent reading. Research on how reading orally versus reading silently impacts comprehension is inconclusive.

Summary

The body of research in education is wide. In the areas of reading and mathematics, research can be found on almost every component of the two. However, the body of research on how the two relate—specifically reading fluency and mathematical problem solving—is limited. Quality education is the foundation for developing successful citizens. The more research can uncover regarding how reading fluency and mathematics relate, the higher the quality of education that can be provided for students across the nation.

CHAPTER 2

REVIEW OF THE RELATED LITERATURE

There is currently a plethora of research related to reading fundamentals in the areas of phonics, phonemic awareness, fluency, vocabulary, and comprehension. Reading consists of these aforementioned five components (Voyager Learning Company, 2006), but it also includes the ability to analyze, synthesize, make inferences, and solve problems. These components and abilities are then used to read text, maps, charts, graphs, and tables, just to list a few (Rangappa, 1993). Considering all that is needed to be an effective reader, research must examine and support all facets of aptitudes that fall under the umbrella of reading. The established research outlines the relationships, often correlational, among these fundamental components. Much is known about the importance of understanding and the use of these relationships in improving student achievement. There are countless resources including scientific-based research, professional articles, and trade books devoted to the areas and importance of reading.

The fundamental area of research in reading that has not gained as much attention as other areas is reading fluency, both oral and silent. The current research is overwhelmingly dominated by studies in the area of fluency and its relationship or predictability of performance in reading comprehension. Few research studies examine the relationship between oral reading fluency and the area of mathematics. More specifically, little research has investigated how reading fluency impacts a student's problem-solving ability. Though a relationship related to how fluently students read and how well they perform in mathematics seems obvious, the amount of research regarding this relationship is lacking. A closer look at how reading fluency plays a part in a student's success in problem solving is needed.

To a great extent, mathematical word problem solving and reasoning is a function of reading. In order for a student to solve a mathematical word problem, he or she must be able to first read and comprehend the problem. Since comprehension is greatly influenced by reading fluency (Beringer et al., 2010; Fuchs, Fuchs, Hosp, & Jenkins, 2001; Rasinski & Padak, 2001; Wise, et al., 2010), it can be assumed that a student's ability to solve a mathematical problem that requires reading is impacted by his or her reading fluency. Although reading fluency's correlation and predictive relationship with mathematical word problem solving would seem evident, little research has been done to support this notion.

Oral Reading Fluency

There are two forms of fluency, oral reading fluency and silent reading fluency. This study specifically uses oral reading fluency as a research variable. Oral reading fluency has been defined as the ability to read accurately, with prosody or expression, using appropriate phrasing and speed (Fountas & Pinnell, 2001; Fuchs et al., 2001; Rasinski & Padak, 2004; Wise et al., 2010). Rasinski et al. (2005) added to this definition by including automaticity as a factor that contributes to oral reading fluency. Automaticity refers to the ability of a student to recognize a word instantaneously and effortlessly instead of spending time decoding the word (Rasinski et al., 2005; Wise et al., 2010). Analysis of a student's oral reading fluency ability was recommended by the NAEP and included the components of accuracy and rate in assessment of the skill (NAEP, 1995). In general, reading fluently is equivocal to reading in the same way you speak.

The definition of oral reading fluency most often refers to accuracy, expression, and rate. However, some researchers have further investigated oral reading fluency. LaBerge and Samuels (as cited in Beringer et al., 2010) developed a theory regarding automaticity in reading. They felt students who lacked automaticity would struggle greatly in the area of oral reading fluency because of the amount of cognitive energy they would have to use to decode unknown words they would encounter in reading. Rasinski and Padak (2004) built on this theory by including in their definition of fluency the need for students to achieve control over lower level or surface-level text. They extended this theory into a three-dimensional model. The model combined the theories of LaBerge and Samuels, Schreiber, and Wagner and Torgesen, and included accurate word decoding, automatic, effortless processing, and prosodic reading (as cited in Beringer et al., 2010). Automaticity in word recall is the component of fluency that helps students read the way they speak. When reading, students, who have to continually decode words, stop the flow of reading. Their attention is then devoted to decoding and not the text.

When students are able to read fluently, they are able to attend to the actual text. Students in the primary grades are using text to learn to read. Chall (as cited in Beringer et al., 2010) identified reading fluency as one of the first stages of reading achievement. A shift in the purpose of reading text is found in about the fourth grade when students begin to read to learn. Much of the requirements in all subject areas of students throughout the school day will involve reading. Their success on this requirements hinges on their ability to read assigned text, directions, and questions. Due to this shift, students must have a mastery of the text, in other words, be able to read it fluently.

When students are reading text fluently, they are not spending time decoding words. Decoding is a lower-level reading task that has negative impact on fluency. This negative impact on fluency then leads to a negative impact on comprehension (Rasinski et al., 2005). The same negative impact holds true for reading accuracy in text. A study completed by Wise et al. (2010) found that even when students read words accurately, the effort to do so can have a negative effect on fluency. When a student is reading either a small amount or large amount of words accurately, if the reading is not automatic, he or she is expending energy on the task, specifically decoding. This expended energy limits cognitive capacity that would otherwise be used for comprehension (Rasinski et al., 2005).

When students do not read fluently, they are not able to access all the information in the text (Fountas & Pinnell, 1996). When the recognition of the words in the text is automatic then students can concentrate mainly on the meaning of the text. Focusing on the meaning of text leads to comprehension and understanding of what is being read. At this point students are able to expand their learning capacity. They are able to read text for a purpose rather than just using text as a means to practice the skill of reading. Automaticity, therefore, leads to the shift where students begin to be able to read to learn instead of learning to read.

Due to the fact that reading is such a complex task, researchers have begun to take a more indepth look at how reading fluency impacts reading as a whole. It is known that automaticity and accuracy impact reading due to the fact that without these skills students must focus mainly on decoding and not meaning. How, specifically, does the complexity of the task of reading interrupt comprehension? Masterson and Apel (as cited in Wise et al., 2010) determined reading is a multistep process that involves accessing stored mental orthographic images, accessing lexical meanings, making connections between sentences, relating current text information to previous information, and finally making inferences. These processes can be further divided into two groups that include the lexical route and the nonlexical route. Accessing stored mental orthographic imagines is part of the lexical route while decoding is part of the nonlexical route (Castles as cited in Wise et al., 2010). The importance of this information is that it supports the need for automaticity and reading fluency. When the processing occurs fluently through these two routes, the result is more cognitive capacity and attention given to the text that was read. This attention in turn leads to comprehension (Wise et al., 2010).

A second version of this theory is proposed by Posner and Snyder (as cited in Baker et al., 2008), specifically relating to automaticity. They determined that automatic word recognition was due to two context-based expectancy processes. First of these is “automatic fast-spreading semantic activation” (Baker et al., 2008, p. 19), meaning that the words are known by sight without using cognitive energy to decode the word. The second part is “slow-acting, attention-demanding conscious use of surrounding context for word identification” (Baker et al., 2008, p. 19), indicating that students are expending large amount of cognition decoding words. Through this, researchers have determined that freeing up cognitive resources leads to better comprehension. This has also lead to the establishment that oral reading fluency is associated with comprehension (Beringer et al. 2010).

Oral Reading Fluency’s Relationship to Comprehension

Oral reading fluency has a positively correlated relationship with comprehension. As the student’s oral reading fluency increases and improves, his or her comprehension increases and improves. Research dating back more than 60 years found faster, more fluent readers have better comprehension. They are overall better readers than those students with slower, dysfluent reading abilities (Rasinski & Padak, 2001). Wise et al. (2010) supported the findings that oral reading fluency is an important and significant predictor of reading comprehension. Specifically, automaticity, a component of oral reading fluency, is the largest contributor to comprehension.

Students' need for automaticity in reading in order to improve comprehension was also determined by Le Berge and Samuels (as cited in Baker et al., 2008) when they found a relationship between automaticity and comprehension. A study of oral reading fluency and comprehension by Beringer et al. (2010) supports the relationship. They determined that oral reading fluency has direct paths to comprehension for both the second and fourth grade students included in their study. The results of their measures found that oral reading fluency did contribute to reading comprehension. Support for this outcome was consistent with results from past research done by Dowhower, Fuchs et al., Jenkins et al., and Wagner and Torgesen, (as cited in Beringer et al., 2010). An additional study of over 1,000 fourth graders done by Fountas and Pinnell (1996) provided further evidence that oral reading fluency is highly related to comprehension. Not only is there a relationship between oral reading fluency and comprehension but also the relationship remains among varying degrees of comprehension among different grade levels (Wise et al., 2010). Progression and achievement at each grade level in school therefore has a common denominator. This commonality is a student's ability to read fluently, focusing strongly on the automaticity component of fluency.

The knowledge that oral reading fluency has an impact on reading comprehension leads to the question of how the lack of fluency and comprehension impacts other areas of learning. If the basis and main contributor to comprehension is oral reading fluency, then lack of fluency may inhibit student achievement in all academic areas, since reading and comprehension of the text is the basis of all other learning. It is to be questioned that if a student cannot read fluently in a science, social studies, or mathematical text, can he or she comprehend the text? According to the research findings, the answer to this question would be no. If lack of reading fluency has a negative impact on comprehension, then those students who struggle with reading fluency will not be able to comprehend the text in order to be successful in other academic domains. Students may be able to achieve and become proficient in most subject areas if reading fluency is improved. Also, accommodating for poor reading fluency by reading text to students may provide teachers with a better picture of what information a student knows if the aspect of reading fluency is controlled.

Oral Reading Fluency's Relationship to Overall Reading Competence

A study specific to using oral reading fluency as an indicator of reading competence was done by Fuchs et al. (2001). In this study, it was unveiled that oral reading fluency consistently provided a basis for determining levels of overall reading achievement. A student who is reading fluently has a strong phonemic awareness and an understanding of phonics, which are needed skills for accuracy and automaticity. A closer look at oral reading fluency confirmed that it is not just an indicator of a student's ability to comprehend literature or non-fiction text. Oral reading fluency represents a student's "global level of reading competence" (Fuchs et al., 2001, p. 251). Baker et al. (2008) stated, "An extensive research base in special and general education provides strong support for the use of oral reading fluency as a measure of reading proficiency" (p. 19). The most salient characteristic of proficient reading is oral reading fluency and was theorized by Adams (as cited in Fuchs et al., 2001), lending additional support to more current research. There is an extensive amount of research supporting oral reading fluency and its overall impact on student achievement.

The intermediate grades of elementary school tend to be where the shift occurs in the expectations for students. Teachers are no longer reading to the students all of the required text, directions, and answers. Students are becoming more independent learners and thinkers. The research by Baker et al. (2008) indicated the relationship between reading fluency and overall student achievement is found most often in students in Grade 3 and higher. The correlation is not limited to upper elementary students alone. A study by Rasinski et al. (2005) strengthened Baker et al.'s study by determining that 28% of the variation in student achievement on a high school graduation test could be accounted for by the students' reading fluency variation. Researchers have found further evidence that oral reading fluency can also be used as a predictor of reading proficiency (Baker et al., 2008). These findings were consistent with Stage and Jacobsen's (2001) research related to predicting student success on mandated assessments using oral reading fluency scores.

Oral Reading Fluency and Silent Reading Fluency

When students read to comprehend, a difference exists when the student is reading orally verses silently. Just how significant this difference may be and how the difference impacts comprehension is not completely understood (Armbruster & Wilkinson, 1991; A. Hale et al., 2011; McCallum, Sharp, Bell, & George, 2004; Swalm, 1972). In some research, it has been found that students comprehend better when reading silently (Hale et al., 2011; McCallum et al., 2004). This increased comprehension may happen because, when silent reading is the process, students are not inhibited by having a listening audience. They are able to read at their own pace, skip words, or reread as needed. Other research has shown that reading orally improves comprehension (Hale et al., 2011; McCallum et al., 2004). The reason may be that students have to attend more closely to the text if they have an audience and that they cannot skip over words they do not know. When reading orally, students are expending all their cognitive energy on the task of reading, which some researchers would conclude increases comprehension due to increased concentration on the text (Hale et al., 2011; McCallum et al., 2004; Miller & Smith, 1985; Swalm, 1972). Other researchers would conclude the amount of energy expended reading orally decreases comprehension. The reason may be that students are working too much on decoding and sight reading and cannot concentrate on text meaning (Hale et al., 2011; McCallum et al., 2004). Still others including Swalm (1972) have found there to be no significant difference in comprehension due to reading process (Hale et al., 2011; McCallum et al., 2004).

Research on how reading ability affects oral and silent reading is also inconclusive (Hale et al., 2011). Some research suggests the reading ability of the students has an effect on how well they comprehend when reading orally verses reading silently. McCallum et al. (2004) discussed that low-level readers showed better comprehension after reading orally than when having read silently. Medium-level readers, however, had better comprehension after reading silently. Those readers with the highest ability showed no difference in comprehension depending on reading mode. This same conclusion was found in research completed by Miller and Smith (1985) and Swalm (1972). In contrast, the 1985 study by Homes and Allison (as cited in McCallum et al., 2004) found no differences in comprehension dependent on reading ability.

Effect on Standardized Test Scores

At the forefront of education today is the topic of state mandated testing. Standardized tests are used and student performance on these assessments functions as the indicator for success or failure under the conditions of the No Child Left Behind Act (U.S. Department of Education, n.d.). Research has been completed using standardized test scores as a data source for results. Research has also been completed to investigate how student ability in reading relates to performance on these tests. It has been determined that oral reading fluency not only is correlated with reading proficiency, but also it has a moderate to strong relationship to performance on standardized assessments (Baker et al., 2008). These findings by Baker et al. (2008) are consistent with a previous finding by Fuchs et al. (2001) that oral reading fluency is a stronger indicator of performance on standardized tests than assessments specifically measuring comprehension.

If the correlation between reading fluency and comprehension exists, it can be determined that reading fluency will impact both positively and negatively student performance on standardized, state-mandated tests. Students who read more words correctly per minute often comprehend at greater rates than those reading fewer words correctly per minute. Students with developed reading fluency may score higher on standardized tests. Students with underdeveloped reading fluency may score lower on standardized tests.

Students who read at a slower rate but comprehend well are at a disadvantage. The amount of time it will take these students to read specific passages, directions, and questions on tests is greater than that of a student who reads a normative number of words per minute. These students will have less time to devote to comprehending the test passages and focusing on directions and questions than those students who are reading at benchmark levels. In addition, most standardized tests are timed, leaving students who read fewer than the needed words per minute for his or her grade level at a huge disadvantage. Too much time will be spent on reading the actual test passages, directions, and questions and less time will be spent on the test questions themselves. The lack of reading fluency and its impact on comprehension will lead to frustration and failure not only on standardized tests but also at school as well (Rasinski et al., 2005).

Measuring and Assessing Oral Reading Fluency

There are many techniques for measuring or assessing oral reading fluency including both formal and informal techniques. The two main components of oral reading fluency used to assess students' achievement are accuracy and rate. Further defined, accuracy pertains to the number of words read correctly and rate pertains to the number of words read in one minute.

Combined, educators obtain a score of words correct per minute (Rasinski & Padak, 2001, 2004; Wise et al., 2010). When a student's oral reading fluency is assessed, the student reads a passage from grade-level material. The student is timed and the words read correct in one minute constitute the oral reading fluency score (Baker et al., 2008; Rasinski & Padak, 2001). This is also referred to as reading rate. Rasinski and Padak (2004) determined that, even though reading rate is not the only component of reading fluency, it has been found to be a useful and valid measure of reading fluency. Oral reading fluency can be measured to determine both students' reading fluency on grade-level text and on that of text at their own personal instructional reading levels. Assessments should be completed on both grade-level and instructional-level text to determine if growth and achievement in fluency is being made. The test of oral reading fluency can be done using texts provided by companies who specifically design both materials and technology for assessing fluency or by using materials already found in the classroom, such as reading textbooks.

Norms for oral reading fluency have been developed for specific grade levels and time of year. Most often, the norm-reading rate is given for fall, winter, and spring. Norms have been established due to the fact that a student's reading rate will grow within and across grade levels (Rasinski et al., 2005). Although these scores differ somewhat among different sources, they tend to align typically within three to five words read per minute. Table 1 contains the norms used by the DIBELS.

Table 1

Norms Used by the Dynamic Indicator of Basic Early Literacy Skills (DIBELS)

Grade	Fall	Winter	Spring
3	77	92	110
4	93	105	118
5	104	115	124

Though normative scores have been developed for Grades 1 through 6 for the DIBELS ORF test, for the purpose of this study only Grades 3, 4, and 5 were needed and provided in the chart. The scores listed indicate the words per minute needed for a student to be considered benchmark or at low risk in the area of reading fluency. It should be noted that these scores are minimal scores for being at low risk. Students reading beyond these normative levels are more likely to remain on grade level and maintain a benchmark level oral reading fluency score (University of Oregon, n.d.a).

Oral reading fluency is considered a curriculum based measure and is the most thoroughly studied and has the most empirical support for its use (Baker et al., 2008; Rasinski et al., 2005). These type of measures, often referred to as CBM, are used to assess whether or not students are making progress in specific, basic skills in curriculum areas such as reading, spelling, written expression, and mathematics (Baker et al., 2008). Additional support of the use of CBM is due to its ease of administration and sensitivity to change (Stage & Jacobsen, 2001). These types of tests are most often timed, which is why they are frequently used for assessing oral reading fluency (Beringer et al., 2010). Two of the most widely used formal CBMs are the DIBELS and AimsWeb (Beringer et al., 2010). Both of these measures also contain an electronic component, which allows teachers to access data through a website and enables scores to be uploaded to a database accessible by school administration and departments of education.

Another, though different, formal oral reading assessment is the specific rating scale, which is in rubric form. This type of assessment, one such that was used in the NAEP fluency study, can be used by teachers while listening to students read aloud from grade-level text (National Center for Educational Statistics, 2002). This particular scale contains four levels with four being the highest level and equating fluent oral reading. Within these levels, students are evaluated based on phrasing, syntax, and expression.

Informal tests can be done quickly by teachers. These informal tests are as simple as listening to students read. As the student is reading, the teacher listens for expression, phrasing, accuracy, and pace. The teacher can develop his or her own form of documentation or note-keeping system to use when evaluating students. By merely listening to a student orally read grade-level text, the teacher will have a good indication of whether or not a student is reading fluently.

Dynamic Indicator of Basic Early Literacy Skills

According to Kim et al. (2010), one of the most frequently used measures of oral reading fluency is the DIBELS assessment. This specific assessment tool has been used widely to meet the criteria of the assessment component of the No Child Left Behind Act of 2001, Reading First. Research studies have shown that DIBELS ORF is an indicator of children's overall reading skills development (Kim et al., 2010).

Mathematical Problem Solving

Mathematical problem solving is a general term used by educators to describe the types of mathematical problems that involve text information and numerical data as well as the skill involved to arrive at correct responses. More specifically, these types of problems are also referred to as word problems or constructed response. An overall description of problem solving is a student's use of all obtained mathematical knowledge to solve problems. These types of problems are usually multiple-step and require multiple mathematical skills.

Mathematical problem solving, specifically solving word problems, has been established as one of the most difficult components of mathematical education (Forsten, 2004; Fuchs et al., 2009; Gersten et al., 2005; J. Hale et al., 2003; Hart et al., 2009; VanSciver, 2009). This specific domain of mathematics requires a multitude of skills in which students must be proficient. These skills in conjunction with reading skills must work together simultaneously in order for students to arrive at a correct solution for any given problem. Beyond reading and comprehending the problem, directions, and question, students must also decide upon a correct method to solve the problem. Once this portion is complete, students must still change words into numbers and equations and finally compute correctly. There are many ways students can make mistakes in problem solving making it difficult to arrive at a correct answer.

Skills Required for Mathematical Problem Solving and the Relationship to Reading

Problem solving requires a distinguished skill set. It necessitates intellect and intelligence to sort through the various pieces of information, both text and numerical, in order to arrive at a correct answer (Manzo, 1975). The amount of skills and processes necessary for problem solving is immense. In general, solving a word problem entails using text to identify missing information, construct the number sentence, derive the calculation problem for finding the missing information, and finally solve the calculation problem (Fuchs et al., 2009).

Researchers, such as Wadsworth, DeFries, Fuller, and Plomin (as cited in Hart et al., 2009), realized there was a high correlation between the genes related to mathematics and reading. A medical correlation is strong evidence that the relationship between mathematics and reading exists. It is important to build upon the medical findings to determine the magnitude of the effect of reading fluency on mathematical problem solving. The correlation between genes related to mathematics and reading would also explain why educators see mathematical difficulties show up frequently in students with reading difficulties. Like reading, students must not only possess these mathematical problem solving skills, they must be proficient with them in order for an accurate line of reasoning to ensue.

Reasoning

Mathematical problem solving involves not just reasoning but abstract reasoning (Manzo, 1975). The student, therefore, must take the provided information found in the problem and make inferences about data which may include not only the numerical data, but also text data such as names of people and situations and turn it into something logical. Overall reasoning skills have an impact on mathematical problem solving ability (Vilenius-Tuohimaa et al., 2008). Along with reasoning, the student must be able to think critically, compute, and apply a process to solve problems (Forsten, 2004). In order to make inferences related to the problem, it must first be read fluently by students, which then leads to comprehension. Students can only begin to reason when they understand the text from which they are to make the judgments.

In addition to reasoning, the student must be able to discern the relationship between and respond to the words and the symbols (Casto, Pennington, Light, & DeFries, 1996; Curry as cited in Roti et al., 2000). J. Hale et al. (2003) supported this need in their findings that the student must sort through important information from the text and then formulate it into an equation. Keeping in mind that the words and symbols are often unknown or unfamiliar to the student, this can impact the level of understanding for many. Beyond recognition of the relationship between the words and the symbols is the knowledge of the actual word or symbol. Related first to decoding and second to fluency, the words and symbols are impacted by students' reading proficiency. Before students can begin to work through the relationship between the symbols, they must recognize the words and read them fluently. This fluent level of reading will eliminate cognitive function being used on the actual reading and preserve it for discerning the relationship between the words and the symbols.

Transferring Information

Transferring information that is already known to new situations is required to adapt prior knowledge to new problems. When students are able to generalize problem-solving strategies and apply or transfer them to new problems, they are developing schemas (Fuchs et al., 2009). Students need to be able to develop these schemas, meaning to categorize a problem, to be able to apply a useful strategy for finding a solution. Transference is also found in reading fluency. Students who recognize a sight word in isolation can then use transference of knowledge to recognize it in text. Students with poor fluency lack the ability to transfer knowledge. This lack of transferring will be observable in both reading fluency and mathematical word problem solving.

Memorization

When investigating the obstacles in achievement for disadvantaged students, Lubienski (2007) concluded that memorization is the foundation of mathematical problem solving.

Flanagan, Ortiz, Alfonzo, and Mascolo (as cited in J. Hale et al., 2003) also found a connection between short term and working memory on problem solving ability). Students who are unable to memorize basic addition, subtraction, multiplication, and division facts along with algorithms will be troubled when attempting to solve word problems which usual require both skills. Memorization difficulties also plague dysfluent readers. They often cannot recall sight words or high frequency words in text. The similarities in deficits for students with reading and/or mathematical disabilities were studied by Geary (as cited in Rasanen & Ahonen, 1995). His study examined the neuropsychological aspect of problem solving and hypothesized that the deficit was due to trouble with representation and retrieval of information from memory, a deficit also found in students with reading difficulties. Most educators would agree that those students who do not have basic mathematical facts committed to memory fail to progress in mathematics and struggle especially with complex problem solving. The same notion holds true for those students who have not committed sight words to memory. They too fail to progress in reading and struggle with reading complex text. When students are unable to memorize basic fundamentals, their achievement will suffer.

Comprehension

When solving word problems, not only must students be able to read the text, they must also comprehend the text. The comprehension portion involves translating the text into a mathematical representation. This skill is classified as verbal comprehension and is determined by reading skill (Jordan, Hanich, & Kaplan, 2003; Stanovich, 1991). This ability requires some level of comprehension. Vilenius-Tuohimaa et al. (2008) determined that to comprehend the readers must first garner the meaning of the sentences and then apply prior knowledge and specific knowledge to the problem. This aspect of comprehension is usually seen in students with higher level reading skills. The difficulty of this type of processing supports the belief that poor readers will also have poor mathematical achievement. There tend to be more ideas per line and per page for mathematical word problems than on problems or questions found in other disciplines (Curry as cited in Roti et al, 2000). This makes the demand for fluent reading high.

Multitude of Combined Skills

A study by Wirtz and Kahn (as cited in Roti et al., 2000) found that problem solving requires reflective thought, trial and error, evaluation, decision making, and other high-level cognitive skills, attitudes, and behaviors. Similar to the findings of Wirtz and Kahn were those of J. Hale et al. (2003) when, after first discovering the predictive power of verbal and performance subtests from WISC-III on word problem skills, determined that a large set of skills were needed to solve these types of problems. These skills encompassed semantic/mathematics knowledge, working memory, executive function, novel problem solving, and visual-perceptual motor processes. These are the same types of skills one would expect to be developed in fluent readers and underdeveloped in dysfluent readers. These skills are also indicative of reading comprehension, which is deeply connected with fluency. It can be hypothesized that lack of proficiency of these skills in the area of reading will imprint on mathematical ability and lack of these same skills in that domain.

Cognitive Energy

Finally, problem solving requires energy and focus on the task. The complexity of the problem is positively correlated with the level of skills needed to solve the problem. As the difficulty of the problem increases, so does the level of skills required to solve the problem. Energy and attention can only be given to a specific portion of these skills at one time. Those students who expend all of their cognitive energy decoding words are left without enough energy to also read fluently. Therefore, the students who are using all of their energy on the reading portion of a word problem will have little if no cognitive energy to disperse to mathematical problem solving. Conversely, fluent reading allows the students to understand and, more importantly in regards to mathematics, interact with what they have, leading to a better chance for correct problem solving (Willis, 2008). Students with a deficit in reading fluency are going to have an arduous task trying to solve word problems. The strain on students with a deficit in fluency will be tremendous and most likely will result in failure to solve the problem.

Types of Word Problems

Within the area of mathematics and word problems in particular, it has been discovered by some researchers that these types of problems always take on general formats. These formats, indicative of the strategy needed to solve them, include compare, change, combine, and equalize (Jordan et al., 2003). Three of these four problems types were also elicited by Vilenius-Tuohimaa et al. (2008) with the only difference being they found an item format classified as focus and did not encounter the equalize format. Fuchs et al., 2009) classified the problems by type. The three types included the *total* problem type, the *difference* problem type, and the *change* problem type. The importance of the problem type allows students to make connections between the problems and apply known rules and strategies in order to come up with a solution.

Relationship to Standardized Testing

“Every test is a literacy test,” stated VanSciver (2009, p. 26) in his article on working with mathematics word problems. Essentially the common denominator among tests—whether formal, informal, standardized, or teacher created—is reading. When looking at solving mathematical word problems specifically, Forsten (2004) commented, “The major problem with word problems is the words!” (p. 20). Before a student can demonstrate mastery on a test in any content, he or she must be able to decipher the questions. The assessor must determine if the errors the tester makes are due to lack of proficiency on the subject matter tested or if the errors are due to lack of reading fluency. The importance of reading ability in assessments is overwhelming. Jordan (2002) reported that good readers performed better on standardized tests of mathematics than students who were poor readers. This information is noteworthy due to the fact that in 1990 the National Council of Teachers of Mathematics identified five mathematical strands. These strands include number/operations, statistics/probability, algebra/functions, measurement and geometry (National Council of Teachers of Mathematics, 2011). All five strands use problem solving and are skills needed to solve mathematical word problems. Standardized tests and curriculum are being aligned with these specific strands.

Analysis of Errors in Problem Solving

When looking at results of student assessment, an analysis of the error patterns should occur. By looking at the individual questions, a breakdown of why the wrong answer occurred can be completed. The first and most obvious type of errors are those found in computation or chose of algorithm. Beyond these obvious mistakes are mistakes made due to reading. When evaluating errors, the examiner can try to determine if errors were made due to lack of problem comprehension overall or if specific mathematical vocabulary impacted the student's understanding. It is also possible that the student used all of his or her cognitive energy in decoding the words and reading the problem, leaving little energy left for attempting to solve the problem.

Vocabulary and Mathematical Word Problems

When presented with a mathematical problem to solve, students must sort through the information given in the problem. A problem involving computation only contains the numbers to compute and the mathematical operation to be used. In essence, this requires only the ability to read numbers. Conversely, some mathematical problems contain words to be comprehended and turned into numbers to compute and mathematical operations to be used. In regards to words in mathematics, it is almost a whole new language. Students will need to read both symbols and words pertaining to mathematics and then comprehend their meaning and how they work together to form the context of the problem.

Within the text of these types of problems, the student will possibly come across three types of words. Word types are defined Beck, McKeown, and Kucan (2002) in their extensive research on vocabulary. They put words into three tiers based on the type of word. Tier 1 words contain basic words, those not requiring instruction in school, such as clock, girl, walk, etc. Tier 1 words are the types of words that comprise the “story” portion of a word problem. Tier 2 words are those found in text and used by mature language learners. Word such as fortunate, haunting, and admit are examples of Tier 2 words. These words, often adjectives and adverbs, are not likely to be found in mathematical problems. Finally, Tier 3 words are those words specific to certain domains of learning. These are words found expressly in science, social studies, or mathematics. Examples of Tier 3 mathematical words include parallel, congruent, and prime. These are the types of words students will most often come across in mathematical problems involving words.

The significance of these words types is that in mathematical problems students will be expected to read and comprehend both Tier 1 and Tier 3 words. The majority of students will have a working knowledge of Tier 1 words (Beck et al., 2002). However, the difficulty in problem solving comes from Tier 3 words. Students must not only be able to decode the word, they must comprehend or know its meaning. The study of how and when words are taught completed by Beck et al. (2002) suggested that Tier 3 words be taught when specific need arises. This implies that mathematics vocabulary words, considered Tier 3, may only be taught or discussed when they are needed to solve problems involving that specific content. Therefore, in a spiral mathematics curriculum, these mathematics vocabulary words will be presented in isolation several times throughout the year. If the curriculum is not spiral in nature, the mathematics vocabulary words may be presented only during that specific lesson. Exposure and use of these words under either curriculum type could possibly be limited. Vocabulary research dictates that students need frequent encounters with words before the words become part of their known vocabulary collection (Beck et al., 2002).

When making judgments concerning a student's performance in mathematics, one must question how vocabulary, specifically those words considered Tier 3, impacts performance. This judgment is two-fold in that a determination of how the mathematics vocabulary impacted the performance. The first question to ask when analyzing a student's incorrect response to problem containing mathematics vocabulary is whether or not the student knows the word by sight or can at least decode the word. On a standardized test, a student may be instantly halted in his or her ability to solve a problem due to simply not knowing the words found in the problem. The second thing to consider is if the student recognizes by sight or can decode the word, does he or she know what it means. Word knowledge is a continuum defined by Beck et al. (2002) as having no knowledge, general knowledge, context-bound knowledge, knowledge but not enough to use it, or rich, decontextualized knowledge. In order for students to be able to solve mathematical problems, the student must have the highest level of knowledge for that word. He or she must know the meaning of the word, how the word relates to other words, and finally how to use the word. Thus, just being able to recognize a word such as congruent in a mathematical problem does not guarantee a working knowledge of the word. There is a need for an analysis of mathematic vocabulary's bearing on student problem solving.

Similar Studies

Multiple studies have been conducted to determine the accuracy in using oral reading fluency scores to predict comprehension ability and overall reading achievement. The results of these studies indicate that oral reading fluency is a significant predictor of not only reading competency, but also how a student will achieve on standardize tests (Keller-Margulis et al., 2008). More specifically, Keller-Margulis et al. found research to support that middle of the year scores on curriculum-based measures of oral reading fluency were strongly correlated to achievement on tests taken within the same academic year.

Ackerman, Anhalt, and Dykman (1996) researched the relationship between mathematics failure and reading disorder in students. Their studies show evidence that children who are diagnosed with reading difficulties will eventually have serious mathematics difficulties. They determined the need for verbal and spatial reason along with memory as needs for students to be successful in mathematics. These same abilities are also needed for success in reading fluency. These findings are consistent with those from Casto et al.'s (1996) study of reading disability as a function of mathematical performance.

In their 2003 longitudinal study of mathematics competencies in children with reading and mathematics difficulties, Jordan et al. declared, "Reading abilities influence growth in mathematics achievement, mathematics abilities do not influence growth in reading achievement" (p. 834). They found that children who read well progress at greater speeds in mathematics than those children who do not read well. This information was supported by Vilenius-Tuohimaa et al. (2008), who concurred that mathematical achievement and reading abilities were closely related. They referred to the skills needed to read as *technical reading*. In addition to Jordan et al.'s (2003) findings related to abilities, they also determined as time progresses and students continue through school, the influence of reading on mathematical competence becomes greater. They determined this struggle begins in third grade and is strongest in the area of mathematical word problems.

In a study conducted by Cain and Oakhill (as cited in Vilenius-Tuohimaa et al., 2008), when students were assigned labels of poor text comprehenders or good text comprehenders, the groups differed in mathematical ability. Mathematical word problems are interrelated to reading comprehension. In other words, to solve mathematical word problems requires strong comprehension which in turn requires strong fluency.

The association between mathematical word problems and comprehension was explored by Vilenius-Tuohimaa et al. (2008). In their study, students were divided into reading groups based on reading comprehension ability. The students were then given a standardized test of mathematical word problems. The results showed that students in the good reading group performed better on both the reading comprehension and mathematical word problems tests than did those students assigned to the poor reader group. This difference was shown to be statistically significant. This research is supported by research done by Rangappa (1993) where he also found that students divided into reading groups based on ability showed a significant difference in mathematical ability. Specifically, those in the higher reading group out-performed those in both the average and low reading groups significantly. There was also a significant difference between the performance in mathematics between the normal reading group and the low reading group with the normal group out-performing the low group. When looking at correlational outcomes, Vilenius-Tuohimaa et al. (2008) found a relationship between mathematical word problems and comprehension. In conclusion, the better the student's reading comprehension skill, the better the performance on mathematical word problems. This study, however, focuses on the area of comprehension and its effect on word problem solving and not the area of oral reading fluency.

Evidence Supporting Importance of the Study

Reading ability has been shown to be associated with academic success. Furthermore, students with high academic performance show significantly higher reading ability (Rangappa, 1993). Today mathematics requires more reading than ever before. A relationship between mathematical performance and reading abilities has been shown in the limited amount of studies done in this area (Vilenius-Tuohimaa et al., 2008). Of the studies that have been completed, many focus on the relationship in performance for students with either or both reading learning disabilities or mathematics learning disabilities (Vilenius-Tuohimaa et al., 2008). Though the studies are limited, ability in reading has been found to be a determinant of mathematical ability (Ballew & Cunningham, 1982; Casto et al., 1996; Muth, 1988; Rangappa, 1993; Rasanen & Ahonen, 1995).

In regards to specific mathematics research, problem solving has received less attention than other areas of mathematics such as computation (Gersten et al., 2005). Among the studies specific to problem solving it has been determined that those students with reading difficulties show different patterns of cognitive deficiency than those students who display mathematical difficulty alone (Vilenius-Tuohimaa et al., 2008). Not only was a difference in cognition displayed, Gersten et al. (2005) discovered through their experimentation that the difference only occurred in two areas, one being solving mathematical word problems. They went on to determine that reading had a negative influence on a student's mathematical development.

Furthermore, they found that even students with specific mathematical difficulties were able to out-perform those students with reading difficulties (Gersten et al., 2005). A study conducted by Fuchs et al. (2009) involved providing an intervention for students in mathematical word problem solving. After the intervention took place, students showed no improvement in their ability to solve word problems. They concluded that the reason for their difficulty is due to their inability to comprehend the problem. The researchers went on to say that their results indicate the lack of language processing skills were the basis of the deficit in mathematical word problem solving competence.

Summary

In conclusion, the relationship between oral reading fluency and mathematical problem solving has seen little research. The components of reading have been widely studied and there are solid, research-based theories on how these components work together to result in achievement. There is much evidence supporting the impact students' fluency levels have on their comprehension ability. One must question how fluency is also impacting students' achievement in other subject areas. Research has also taught us that the area of mathematics is complex and requires many skills. It seems students must be proficient at not only mathematics skills but also reading skills to achieve in the area of mathematical problem solving. There is a need for further investigation to determine to what extent reading fluency impacts mathematic problem solving. A key component to that research will be the relationship between the two disciplines.

CHAPTER 3

METHODOLOGY

This study contains both quantitative and qualitative analyses. The purpose of the quantitative study was to investigate whether or not mathematical problem solving scores can be predicted from DIBELS ORF scores. This portion of the study used linear regression for the analysis. An investigation was also done to determine if there were gender differences for predictability. A descriptive analysis of the regression was included for gender. The qualitative portion of the study involved examining actual student responses to constructed response questions from the Acuity Diagnostic Assessment. Error patterns related to students' fluency level were determined. After the error patterns were established, an analysis of how the patterns are impacted by gender was also conducted.

Quantitative Study

Description of the Population

The data in this study were derived from scores from third, fourth, and fifth grade students at a specific elementary school in the west central portion of Indiana. The total enrollment for the school was 328 students. There were a total of 150 scores used in the study. The students ranged in age from nine to 12 years old. During the 2009-2010 school year, 56 third grade students, 51 fourth grade students, and 53 fifth grade students were enrolled. Among the total student population, there were 23 Black students, four Asian or Pacific Islander students, seven Hispanic students, 266 White students, and 28 multiracial students. The school was located in a high poverty area: 260 students receiving free meals, 23 students receiving reduced priced meals, and 45 students paying full price for meals. The group of male and female participants included general education students. Data from students identified as having specific learning disabilities, mild cognitive disabilities, or communication disorders were eliminated from the study to avoid a skew in the data. These categories could be used to obtain additional information in the future.

Description of Variables Used

There were two variables used in the quantitative portion of the study. These variables included the students' scores on DIBELS ORF tests and the students' scores for mathematics constructed response from the ISTEP+ test. Scores were from the 2009-2010 school year and those students who were not present for both test windows and did not have scores for both were eliminated from the study. Permission to use the data was granted from the Indiana Department of Education and the Vigo County School Corporation (Appendix A).

Research Questions

Research Question 1. Among third, fourth, and fifth grade students, is there a significant relationship between their oral reading fluency scores and mathematics constructed response scores?

Research Question 2. Is the correlation between oral reading fluency scores and mathematics constructed response scores stronger for one gender?

Research Question 3. Among third, fourth, and fifth grade students, are DIBELS oral reading fluency scores and ISTEP+ constructed response scores correlated?

Research Question 4. Is the correlation between DIBELS oral reading fluency scores and ISTEP+ constructed response scores stronger for one gender?

Null Hypotheses

$H_0$1: There is no predictability between oral reading fluency scores and mathematical problem solving.

$H_0$2: There is no difference in the correlation between oral reading fluency scores and mathematical problem solving based on gender.

$H_0$3: There is no predictability between oral reading fluency scores and mathematical problem solving scores.

$H_0$4: There is no difference in the correlation between oral reading fluency scores and mathematical problem solving scores based on gender.

DIBELS Oral Reading Fluency

The DIBELS is a set of procedures and measures for assessing the acquisition of early literacy skills from kindergarten through sixth grade (University of Oregon, n.d.b). The ORF portion of the test is a standardized, individually administered test of accuracy and fluency with connected text. The passages are calibrated for the goal level of reading for each grade level. Student performance is measured by having the students read a passage aloud for one minute. The number of correct words per minute from the passage is the oral reading fluency score (University of Oregon, n.d.b). The test is given three times a year by the classroom teacher or reading specialist using a Palm Pilot and a book for the students with specific text. This test is given to all third, fourth, and fifth grade students enrolled at the school during the testing window. The students read the passage specific to the testing period from a book. The teacher has the same text on a Palm Pilot screen and records needed information on that device. The teacher reads scripted instructions to the student and he or she begins to read. When the student reads the first word, the teacher touches that word on the screen indicating either correct or incorrect pronunciation and a built in timer begins. The teacher follows along as the student reads and touches any word the student reads incorrectly. The teacher taps it again if the student self corrects and reads the word correctly. If the student pauses for three seconds, the teacher tells the student the word and touches it on the screen. All words that are touched turn red and indicate errors in reading. Words that are omitted are also marked; however, words that are inserted are not recorded. At the end of one minute, the last word read is marked on the screen with a bracket and the number of words correct per minute is calculated. This test is given in the fall, winter, and spring of the school year to establish benchmark oral reading fluency levels. For the benchmarking period, three passages are read and the average of three passages becomes the score. Throughout the year the teacher can use the same technique to monitor the student's fluency progress. During a progress monitoring test the student reads only one passage to receive a score.

DIBELS ORF tests have norm-referenced scores that dictate the reading level for each student. There are three levels, which include benchmark, strategic, and intensive. These levels indicate the minimum level of proficiency at that level. A benchmark score indicates a student is at low risk for reading failure, a strategic score indicates a student is at some risk for reading failure, and an intensive score indicates a student is at high risk for reading failure. The levels are color coded green, yellow, and red respectively. These data are uploaded to a database that contains the scores for both benchmark and progress monitoring. Scores for students are available for all DIBELS tests taken at each grade level during the time they have been enrolled at the school. Summary reports are available for teachers as well as individual student reports, which are provided to parents.

For the purpose of this research, scores from the middle of the year benchmarking window were used. The scores from this assessment window were used because this data was established closest to the ISTEP+ assessment window. The scores are reflective of students' achievement in the late winter/early spring of the specific school year. The middle of the year or winter benchmark period took place the second and third weeks of January. These scores were established first in relation to the other scores used in this study.

ISTEP+ Standardized Test

The ISTEP+ measures student achievement in the subject areas of English/language arts, mathematics, science, and social studies. In particular, ISTEP+ reports student achievement levels according to the Indiana Academic Standards that were adopted in November 2000 by the Indiana State Board of Education. A constructed response assessment and a multiple-choice assessment are used to measure these standards; they are required components of the ISTEP+ program (Indiana Department of Education, n.d.).

The ISTEP+ test is given in the spring of the school year and is divided into two testing sections. The test was given to all third, fourth, and fifth graders who were enrolled during the testing window. If they were enrolled at another school in Indiana during the testing window, they also took part in the test; however, their scores may not have been available. If students were enrolled at another school in the same county as the test sample, their scores were accessible and were used in the study.

The first portion of the test is given in March and consists of the constructed response assessment. On this portion of the test, the student is required to read and analyze text and write answers to questions and provide explanations. For the mathematical portion specifically, the student is required to answer three to five questions dependent on grade level. These questions have multiple parts and have multiple point values. A student may earn full, partial, or no credit for the problem. These problems all take on the format of mathematical word problems in which the students are asked to answer a question, showing their work, and then answer the question. Next, a follow-up question is asked and the students again show their work and provide an answer. Then the students may or may not be asked to provide an explanation of their work or answer an additional question in writing.

The second portion of the test is multiple choice and is given at the end of April. On this portion of the test, the students are required to read and analyze text. Then they must choose an answer from a selection of four answers. The multiple choice questions are not worth multiple points and no partial credit is given. Answers are counted either correct or incorrect. The students may need to work out mathematical problems on separate paper in order to solve the problems. This work is not submitted as part of the test to be scored.

Students receive two main scores for their performance on the ISTEP+ test. One score is for English/language arts and one score is for mathematics. These are scale scores and are connected to achievement levels. There are three levels of achievement pass, pass+ and did not pass. The scale score ranges for each achievement level are outlined on the score sheet. In addition to achievement level, a breakdown of scores is also provided. This report presents how students perform on each Indiana Academic Standard specific to English/language arts or mathematics. It is the score students would be expected to receive if there were 100 items for that specific standard. Along with the expected score is the target score expected for each grade level, the state average, and an indication of whether students are at, above, or below the target scored. A breakdown of performance on the constructed response portion of the test is also provided. Constructed response refers to questions in which students are required to read a problem, solve the problem, and then write an explanation related to the problem. The explanation portion can range from simply explaining in words the steps for solving the problem to explaining how to solve a similar problem with different numeric values. For mathematics specifically, the problem number, standard, and number of points received out of the number of points possible are given. A summary sheet or score report is provided to both the parents and the schools.

For the purpose of this study, scores from the constructed response portion of the test were used. The specific score used was the problem-solving score found under the student's performance on Indiana academic standards. This score indicates how a student would perform if there were 100 items for that specific standard. This score was examined in relationship to the DIBELS ORF score for the quantitative analysis. This same score was also used for the qualitative analysis. I looked at the students' actual written work on constructed response questions to determine error patterns. The constructed response portion was taken first in March and the multiple choice portion was taken second in April. Both scores were established after the ORF scores.

Design and Data Analysis

A linear regression design is appropriate for this analysis. As presented by Gravetter and Wallnau (2007), this research technique uses hypothesis testing to determine regression between two variables. The goal of regression is to find the best fitting straight line for the data. This line can be defined by the linear equation $Y = bX + a$, where Y represents the slope or the rate of increase in Y as X increases. This regression equation was used to make predictions about scores. The scores from DIBELS ORF and ISTEP+ problem solving, which was gained from performance on constructed response items, was used. The X value consisted of the DIBELS scores that predicted the Y value, which represented mathematics problem-solving scores. Unless DIBELS ORF scores and mathematics problem solving are perfectly correlated, there will be some error in the prediction. This error is equal to the difference between the actual mathematical problem solving scores (Y) and the predicted mathematical problem solving scores (Y). Once the regression equation is established a descriptive analysis of how the equation differs among gender was determined. An examination was done to determine if the correlation was stronger for girls or for boys. The standard error of estimate was also predicted. This determined how accurately the regression equation predicted the mathematical problem-solving scores (Y). The greater the magnitude of the correlation, the less the error; the less the magnitude of the correlation, the greater the error. The standard error of estimate was also examined based on gender.

The tests of significance and confidence intervals were applied (Lomax, 2007). Tests of significance were completed to determine whether or not DIBELS (X) is a significant predictor of mathematical problem solving scores (Y). These tests were performed for the data as a whole and specifically for gender groups. The first test to be used was the test of significance of r^2_{xy}. This test, called the coefficient of determination, showed the proportion of variation in problem solving scores (Y) predicted by DIBELS scores (X). This result must be different from zero and significance at the .05 level was determined. A confidence interval was computed to determine how confident I was that a particular DIBELS score (X) predicted the mean value for problem solving (Y). The final test to be conducted was the prediction interval for individual values for mathematical problem-solving (Y). This test can be used in the future when the DIBELS (X) score is known and the mathematical problem-solving score (Y) is not known (Lomax, 2007).

The data to be analyzed were compiled by a current classroom teacher from the school the sample population attends. This teacher removed any identifying information from the data. This teacher gave the data to an educational assistant at the same school. The educational assistant randomly assigned a specific number to the data pieces for each student. The students/subject were only identifiable by number. No list was generated to connect the assigned number to the student. The collection and use of this data was approved by the school principal, Director of Elementary Education and Title One Services of the school corporation, and by the Chief Assessment Officer of the Indiana State Department of Education.

Qualitative Study

Description of the Population

For the qualitative portion of the analysis, the data were pulled from the same source of participants as the quantitative portion.

Research Questions

Research Question 5. Among third, fourth, and fifth students what common error patterns related to reading fluency can be detected on ISTEP+ mathematical constructed response and Acuity Diagnostic Assessment?

Research Question 6. What differences exist between genders in common error patterns related to reading fluency on the ISTEP+ mathematical constructed response and Acuity Diagnostic Assessment?

Research Question 7. Among third, fourth, and fifth grade students, what errors in mathematical problem solving ability are related to mathematical vocabulary knowledge?

Research Question 8. What differences exist between genders in errors in mathematical problem solving ability related to mathematical vocabulary knowledge?

Research Question 9. Among third, fourth, and fifth grade students, what errors in mathematical problem solving ability are related to the amount of reading of text in the problem?

Research Question 10. What differences exist between genders in errors in mathematical problem solving ability related to the amount of reading of the text in the problem?

Description of Variables Used

There were three variables used in this portion of the study. These variables included a student's score on DIBELS ORF tests, mathematical constructed response portion of the ISTEP+ test, and Acuity Diagnostic Assessment. Scores were from the 2009-2010 school year and those students who were not present for all three test windows and did not have data for all three were eliminated from the study.

I looked at the constructed response portion of the ISTEP and the Acuity Diagnostic Test separately. The questions and corresponding answers for the Indiana academic standard of mathematical problem solving were examined and the Acuity test in its entirety was examined. Once the error patterns were established, an analysis was done to determine if the errors were more common among specific genders. In looking at these assessments, I looked for error patterns in problems for both assessments. The following were possible error patterns I looked for:

1. Did the errors seem to be caused by lack of knowledge of mathematical vocabulary word(s)? For some questions a definition of the mathematical vocabulary word was given. An incorrect response when the definition was provided indicated lack of comprehension of the definition. If the definition was not provided there may have

been a different cause for the error. For example, students make errors on a question in which they must find *area* because they do not know the meaning of *area*. One indicator that students do not comprehend a provided definition or do not know the definition of the mathematics word when the definition is not provided could be the answer provided. For example, if the student calculated *perimeter* instead of *area*, it could be determined that there was a lack of comprehension of the meaning of the word *area*.

2. Did the errors seem to be caused by large amounts of text for students to read? For example, the problem has multiple lines of text and background information before and after the actual problem. Often constructed response questions contain unfamiliar, ethnic-derived names along with descriptive words or phrases thath add details to the "story" portion of the problem. Questions that contain large amounts of text were compared to questions requiring the same skill with little or no text. For example, questions that test students' ability to multiply two digit numbers by one digit numbers may be included in the assessments. This skill could be tested in multiple formats including a constructed response setup or a problem written numerically with only the word *solve* in the directions. Students who incorrectly answered constructed response type questions but correctly answered numerically written questions covering the same skill may be incorrectly answering the Constructed Response question due to the amount of reading required.

3. Did the errors seem to be caused by lack of knowledge of word meanings in the context of mathematics? For example, students are told how numbers *differ* when asked to tell the *difference*. When looking at the words found in a constructed

response type problem, some of the words in the questions may have had multiple meaning. If so, an examination of how the question was answered could be done to determine if the students were using a different meaning for a given word instead of the mathematical meaning.

Mathematical Constructed response from ISTEP+

The mathematical constructed response portion of the ISTEP+ is given during the first testing window. This part of the test is given with the English/language arts and specific content area tests. The test consists of three to five multiple-part questions.

This test requires students to read questions, show their work, provide an answer, and also provide an explanation. Each question is usually worth four points. The first point is earned by showing a correct mathematical process. Students receive credit for this portion regardless of a correct answer. This component is assessed to determine if students know the correct mathematical process to use. The second point in earned from the answer. Students must have a correct answer written on the answer line to receive credit for this component. The third question is typically a follow-up to the first and second questions. It is in story problem form, requiring students to read text before supplying an answer. A correct answer to this portion results in an additional point. The final component to the question is the explain portion. There are multiple possibilities of what the student may be required to explain for this portion of the test. One option may require the students give an explanation of how they solved the problems. Another option may give students additional and different information related to the first problem and ask students to explain how they would get the answer. A final option is the same type of problem as the first two with different values. The students then describe how they would arrive at an answer. Each answer is worth one point and students may receive partial credit.

The school receives score summaries for both the constructed response and multiple choice portions of the test. They also receive a downloadable copy of the students' actual work from the constructed response test. Each student who participated in the test has a copy of his or her handwritten work uploaded to a PDF file that can be accessed and printed along with the score summary sheet by the school.

Acuity Diagnostic Test

The school that the participants attend also conducts a test in grades three, four, and five created by CTB/McGraw Hill called Acuity Diagnostic Test. It is a comprehensive test developed to assess student proficiency on state academic standards (CTB McGraw Hill, n.d.).

The test is given four times per school year. This test is taken on the computer and contains 30 multiple choice questions. All students enrolled at the school during the test window participate in the test. If a student was not enrolled during the testing window, his or her score was not included in the qualitative study.

Acuity Diagnostic Test covers specific Indiana academic standards. The test contains multiple choice questions relating to each tested standard. These are skills students need to know for each specific grade level. Knowing which standard is being tested is useful so I would be able to determine specifically which skills were being tested on specific questions. Due to the computer format, students must complete any work needed to solve a problem on a separate paper which is provided to them before the start of the test. The questions are presented in a random order and have four answer choices from which students must select a correct answer.

When the test is completed, the results for individual students can be found on the Acuity website. From this website, reports can be retrieved detailing both individual and class performance. The reports outline which questions students missed and which standard was addressed on that specific question. These reports are available for the classroom teacher and the parents.

For the purpose of this study, scores from the third assessment given during the school year were used. The third assessment window was the month of March. The third assessment scores were being used since they were established closest to the time the other scores being used were established. These scores were established third in relation to the other scores used in this study.

After the error patterns were determined, I then compared the errors to oral reading fluency level of the student making the error to determine if errors specific to reading occurred more often among students with intensive ORF levels. The results and a discussion of any patterns or relationships that were observed are included in Chapters 4 and 5.

Design and Data Analysis

The same data used in the quantitative analysis and data from the Acuity Diagnostic Test were used for this portion of the study. DIBELS ORF scores were constant and already established. I examined actual student tests from ISTEP+ mathematical constructed response and Acuity Diagnostic Assessment to determine patterns.

For the ISTEP+ mathematical constructed response tests, I examined the actual tests completed by students. These tests were copies that showed the students' work and answers. The ISTEP+ score sheet indicated the amount of credit a student received for each question. The Acuity Diagnostic Assessment data came from an item analysis matrix report. This report showed which questions students answered correctly and incorrectly along with the answer choice they selected. A copy of the test questions was used to analyze how or if error patterns can be established.

Once these patterns were established, an analysis of how they related to DIBELS oral reading fluency scores was completed. I investigated to see if the errors were made frequently by students at the same oral reading fluency level. A determination was made for each reading level as to which types of error patterns one would expect to find.

Summary

The methods and procedures for data collection and the statistical methods for data analysis were presented. Descriptions of the variables along with descriptions of the population used were given. The purpose of the quantitative study was to investigate whether DIBELS oral reading fluency scores can predict ISTEP+ mathematics problem solving scores. The purpose of the qualitative study was to establish error patterns in mathematical problem solving and to determine the frequency of occurrence in specific oral reading fluency levels.

CHAPTER 4

DATA ANALYSIS

The purpose of the study was to investigate the predictability and relationships between oral reading fluency and mathematical problem solving ability. This study examined the relationship between DIBELS ORF scores and ISTEP+ mathematical problem solving scores. Through quantitative analysis, a positive correlation was found between the two scores. A qualitative analysis was also conducted. This analysis examined error patterns found for students based upon gender and reading fluency level. Analysis of the test questions was also conducted in order to establish specific error patterns.

Quantitative Data Analysis

Statistical tests were performed using DIBELS ORF scores as a predictor variable and ISTEP+ mathematical problem solving scores as a response variable. The analysis included descriptive statistics, correlation, and regression models. Discussion of results together with tables and graphs are found in this chapter.

Description of the Population

The data used for the analysis was from ISTEP+, Acuity Diagnostic, and DIBELS ORF tests administered to all third, fourth, and fifth graders at an elementary school during the 2009-2010 school year. The specific elementary school was located in the west central portion of Indiana. The total enrollment for the school was 328 students. There were a total of 121 scores used in the study. The students ranged in age from nine to 12 years old. During the 2009-2010 school year, 56 third grade students, 51 fourth grade students, and 53 fifth grade students were enrolled. Among the total student population, there were 23 Black students, four Asian or Pacific Islander students, seven Hispanic students, 266 White students, and 28 multiracial students. The school was located in a high poverty area and had 260 students receiving free meals, 23 students receiving reduced priced meals, and 45 students paying full price for meals. The group of male and female participants included general education students. Data from students identified as having specific learning disabilities, mild cognitive disabilities, or communication disorders were not included in the study. This was because students receiving special education services also received test accommodations. These accommodations included, but were not limited to extra time and having the mathematics constructed response questions read to them. Since a variable used in the study was oral reading fluency, it was appropriate to eliminate those students having the test read to them to avoid a skew in the data.

Descriptive Statistics

The analyses were conducted for the whole group of participants (N = 121), for the male group (N = 56), and for the female group (N = 65). Groups were identified in tables and graphs as *whole group* indicating data for both male and female students, *Male* indicating data from only male students and *Female* indicating data from only female students. ORF scores indicated the number of words read correctly in one minute were used, and a mean for these scores was calculated. The mean for the entire group was 105.90. The mean for boys only was 106.32. The mean for girls only was 105.54. ISTEP+ mathematical problem solving scores indicated the expected number of mathematical problem-solving items a student would have answered correctly had there been 100 items. The mean score of ISTEP+ mathematical problem solving for the entire group was 39.8. The mean for boys only was 45.93, and the mean for girls only was 34.6. Table 2 shows the descriptive statistics for all three groups.

Table 2

Means and Standard Deviations for Measures and Demographics

Measure	*M*	*SD*	*N*
Whole Group DIBELS Oral Reading Fluency	105.9008	34.91881	121
Male DIBELS Oral Reading Fluency	106.3214	36.63089	56
Female DIBELS Oral Reading Fluency	105.5385	33.65732	65
Whole Group ISTEP+ Mathematical Problem Solving	39.7686	22.18587	121
Male ISTEP+ Mathematical Problem Solving	45.9286	19.88591	56
Female ISTEP+ Mathematical Problem Solving	34.6000	23.01481	65

Correlation of DIBELS ORF and ISTEP+ Mathematical Problem Solving

A correlation was sought between the DIBELS ORF and ISTEP+ mathematical problem solving scores to answer the following research questions:

Research Question 1. Among third, fourth, and fifth grade students, is there a significant relationship between their oral reading fluency scores and mathematics constructed response scores?

Research Question 3. Among third, fourth, and fifth students, are DIBELS oral reading fluency scores and ISTEP+ constructed response scores correlated?

A Pearson Correlation was completed for DIBELS ORF scores and ISTEP+ mathematical problem solving scores. This test measures the degree and direction of the linear relationship between the two variables. Results indicated that for the whole group, DIBELS

ORF score (X), had a positive linear relationship with the response variable, ISTEP mathematical problem solving score (Y). For the whole group, the two scores were significant at the 0.01 level and moderately positively correlated ($r = .53$, $p < .01$, two-tailed).

Research Question 2. Is the correlation between oral reading fluency scores and mathematics constructed response scores stronger for one gender?

Research Question 4. Is the correlation between DIBELS ORF scores and ISTEP+ constructed response scores stronger for one gender?

Results indicated for boys and girls the predictor variable, DIBELS ORF score (X), had a positive linear relationship with the response variable, ISTEP mathematical problem solving score (Y). The boys had a low positively significant correlation ($r = .344$, $p < .01$, two-tailed). The girls had a strong positive correlation ($r = .710$, $p < .01$, two-tailed). This correlation was also found to be significant. Though both correlations were significant, the girls had a stronger correlation than that of the boys. Table 3 shows the correlation between scores for all groups.

Table 3

Correlation of DIBELS Oral Reading Fluency Scores and ISTEP+ Mathematical Problem Solving Scores

Correlations	DIBELS Oral Reading Fluency
Whole Group ISTEP+ Mathematics Problem Solving	.530*
Boys ISTEP+ Mathematics Problem Solving	.344
Girls ISTEP+ Mathematics Problem Solving	.710

Note. *Correlation significant at the 0.01 level (two-tailed)

The scatterplot graph of the two scores shows a positive correlation between the scores, meaning as the DIBELS ORF score increases, the ISTEP+ mathematical problem solving score also increases. The graphs for whole group (Figure 1), the boys (Figure 2), and the girls (Figure 3) are displayed below.

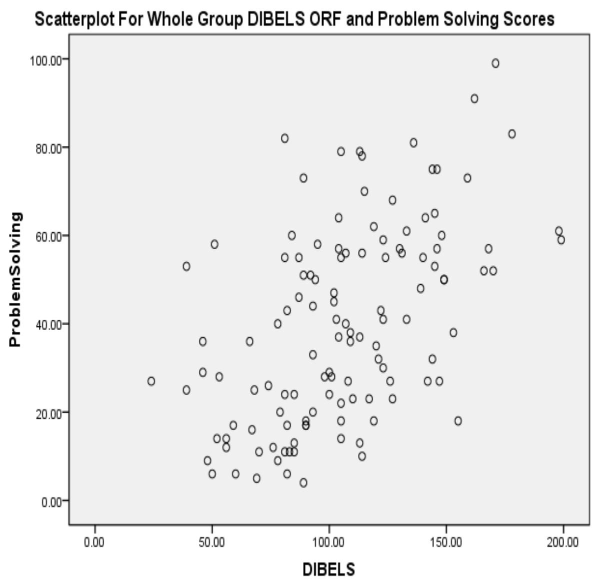

Figure 1. Scatterplot of DIBELS ORF score (X) and ISTEP+ mathematical problem solving (Y) for the whole group

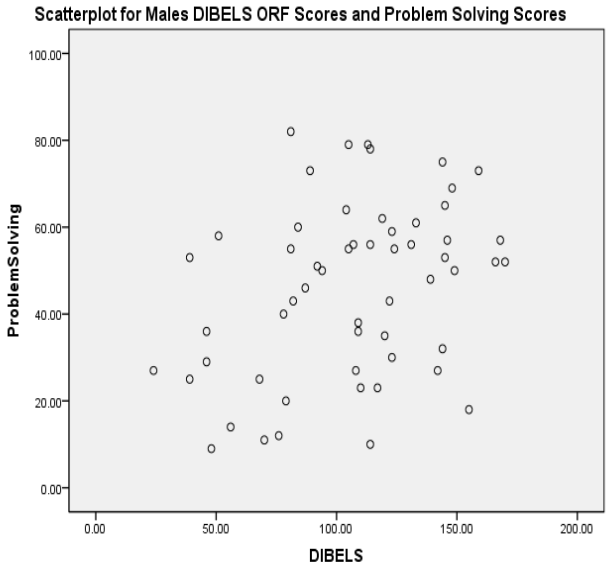

Figure 2. Scatterplot of DIBELS ORF Score (X) and ISTEP+ mathematical problem solving (Y) for the male group

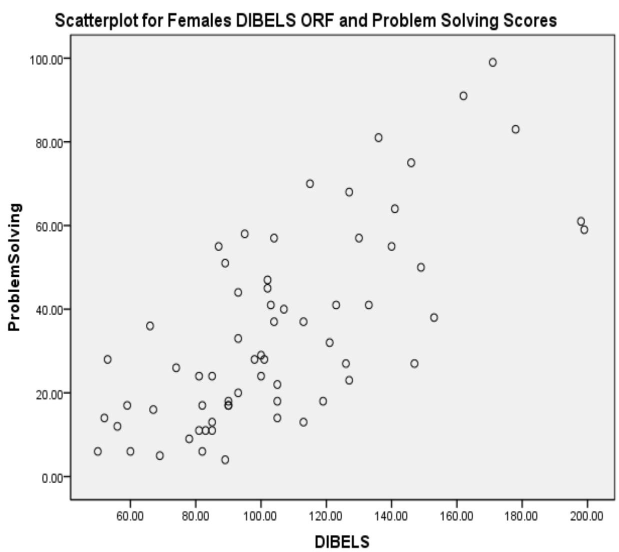

Figure 3. Scatterplot of DIBELS ORF Score (X) and ISTEP+ mathematical problem solving (Y) for the female group

Regression Equation

The goal of regression is to find the best fitting straight line for the data. This line can be defined by the linear equation Y=bX + a, where Y represents the slope or the rate of increase in Y as X increases. A regression equation was computed to allow for prediction of ISTEP+ Problem Solving scores from DIBELS ORF scores. The estimated regression model was Y′ = .334(DIBELS ORF score) + 4.40, $N = 121$. The equation was statistically significant at the .01 level ($F(1, 119) = 45.42$, $p < .01$).

A regression equation was computed for boys. The estimated regression model was Y′ = .187(DIBELS ORF score) + 26.064, $N = 56$. The equation was statistically significant at the .01 level ($F(1, 54) = 7.255$, $p < .01$). A regression equation was also computed for the girls. The estimated model was Y′ = .485(DIBELS ORF Score) -16.620, $N = 65$. The equation was statistically significant at the .01 level ($F(1, 63) = 63.95$, $p < .01$).

Unstandardized Regression Coefficient

The significance of the regression was used to determine if the regression coefficient was different from zero. For the whole group data, regression coefficient was significantly different than zero. The unstandardized coefficient for the whole group DIBELS ORF was .334. This was a positive regression coefficient that was significant (t (119) = 6.74, $p < .01$). This meant that for every one unit increase in DIBELS ORF scores, there would be a .334 unit increase in ISTEP+ mathematical problem solving.

Unstandardized regression coefficients were also calculated for the gender groups. For the boys the data showed the regression coefficient was significantly different from zero. The unstandardized coefficient for the boys DIBELS ORF was .187. This is a positive regression coefficient that is significant (t (54) = 2.7, $p < .01$). This meant that for every one unit increase in DIBELS ORF scores, there would be a .187 unit increase in ISTEP+ mathematical problem solving scores. The girls data also showed a regression coefficient that was different from zero. The unstandardized coefficient for the girls DIBELS ORF was .485. This regression coefficient is positive and significant (t (63) = 8.0, $p < .01$). This meant for every one unit increase in DIBELS ORF scores, there would be a .485 increase in ISTEP+ mathematical problem solving scores. Table 4 shows the unstandardized regression coefficients for all three groups.

Table 4

Regression Equation and Unstandardized Regression Coefficient

Regression Coefficients	Unstandardized Coefficients B
Whole Group DIBELS ORF	.334
Whole Group Mathematical Problem Solving	4.400
Male Group DIBELS ORF	.187
Male Group Mathematical Problem Solving	26.064
Female Group DIBELS ORF	.485
Female Group Mathematical Problem Solving	-16.620

Coefficient of Determination

Using an ANOVA it was found that the coefficient of determination was significantly greater than zero for the whole group. The value of r^2 indicated how much ISTEP+ mathematics problem solving scores can be explained by DIBELS ORF Scores. The model for the whole group has an r^2 value of .28 indicating that 28% of the variance in ISTEP+ mathematical problem solving scores can be accounted for by DIBELS ORF scores. The coefficient of determination also was statistically significant at the .01 level (r^2 (1, 119) =.28, p<.01).

An ANOVA was also conducted for the boys and girls. For both groups it was found that the coefficient of determination was greater than zero. The model for the boys had an r^2 value of .12 indicating that 12% of the variance in ISTEP+ mathematical problem solving scores can be accounted for by DIBELS ORF scores. The coefficient of determination also was not statistically significant (r^2 (1, 54) =.12, p > 01). The model for the girls had an r^2 value of .50 indicating that 50% of the variance in ISTEP+ mathematical problem solving scores can be accounted for by DIBELS ORF scores. The coefficient of determination also was statistically significant at the .01 level (r^2 (1, 63) =.50, p < 01). Overall the coefficient of determination was only statistically significant for the whole group and the girls.

Standard Error of Estimate

The standard error of estimate was predicted. This determined how accurately the regression equation predicted the mathematical problem solving scores (Y). For the whole group analysis the standard distance between actual data points and the regression line is 18.95, indicating the error between the actual ISTEP+ mathematics problem solving scores and the predicted ISTEP+ mathematical problem solving Scores. For the boys, analysis the standard distance between actual data points and the regression line is 18.84. Finally, for the girls analysis the standard distance between the actual data points and the regression line is 16.34. These errors measure the dispersion of points about the regression line, therefore measuring the accuracy of the prediction equation.

Confidence Intervals

A confidence interval was computed to determine how confident the researcher could be that a particular DIBELS score (X) would predict the mean value for ISTEP+ mathematical problem solving Scores (Y). The confidence interval for the whole group was $b = .236 \leq b \leq .432$. This meant that 95% of the time it can be expected that the slope of the regression line will fall between $b = .236 \leq b \leq .432$. This indicates that for the whole group every increase in DIBELS ORF scores, an increase in the ISTEP+ mathematical problem solving score should be between 2 to 4 points ($t\ (119) = 6.74$, $p < .01$).

The confidence interval for the Boys was $b = .048 \leq b \leq .326$. This meant that 95% of the time it can be expected that the slope of the regression line will fall between $b = .048 \leq b \leq .326$. This indicates that for the boys every increase in DIBELS ORF scores, an increase in the ISTEP+ mathematical problem solving score should be between 0 to 3 points ($t\ (54) = 2.7$, $p < .01$).

The confidence interval for the Girls was $b = .364 \leq b \leq .607$. This meant that 95% of the time it can be expected that the slope of the regression line will fall between $b = .364 \leq b \leq .607$. This indicated that for the girls every increase in DIBELS ORF scores, an increase in the ISTEP+ mathematical problem solving score should be between 4 to 6 points ($t\ (63) = 8.0$, $p < .01$). Table 5 contains these data.

Table 5

Confidence Interval

		Sig.	Lower Bound	Upper Bound
Whole Group DIBELS Oral Reading Fluency score	.472	.001	1.138	4.862
Boys DIBELS Oral Reading Fluency score	.700	.009	.048	.326
Girls DIBELS Oral Reading Fluency score	.000	.001	.364	.607

Prediction Interval

The final test to be conducted was the prediction interval for individual values for mathematical problem solving (Y). This test can be used in the future when the DIBELS ORF score (X) is known and the ISTEP+ mathematical problem solving score (Y) is not known. It was concluded for the whole group that 95% of the time that the average ISTEP+ mathematics problems solving score for the given DIBELS ORF score is within 12.41 and 70.86 points of the actual score. For the boys that 95% of the time that the average ISTEP+ mathematics problems solving score for the given DIBELS ORF score is within 30.55 and 57.83 points of the actual score. For the girls that 95% of the time that the average ISTEP+ mathematics problems solving score for the given DIBELS ORF score is within 7.65 and 79.99 points of the actual score as presented in Table 6.

Table 6

Prediction Interval

Predicted Value	Minimum	Maximum
Whole Group DIBELS Oral Reading Fluency score	12.418	70.858
Male Group DIBELS Oral Reading Fluency score	30.550	57.830
Female Group DIBELS Oral Reading Fluency score	7.650	79.990

Summary

In conclusion, correlations and regression analyses were conducted for the entire data set combined and then parsed by gender. The data showed a significant correlation between DIBELS ORF scores and ISTEP+ mathematical problem solving scores. Regression equations were established in order to be able to predict ISTEP+ mathematical problem solving scores from ORF scores. Equations were formed for all three groups and found to be significant. From these data, it is confirmed that a significant relationship exists between DIBELS ORF and ISTEP+ mathematical problem solving.

Qualitative Data Analysis

A qualitative analysis was completed to establish error patterns in mathematical problem solving relating to reading fluency. The tests examined for errors, from the 2009-2010 school year, included the ISTEP+ and Acuity Diagnostic Assessment for mathematics. The information gathered was examined as a whole and also disaggregated into gender groups and reading levels. The reading levels were derived from scores achieved on the DIBELS test, specifically ORF.

Description of the Population

For the qualitative portion of the analysis, the data were pulled from the same source of participants as the quantitative portion. Table 7 shows the disaggregation of the information. For each grade level, students were divided into gender groups and the number of students in each group was indicated.

DIBELS ORF uses three reading levels based upon the number of words read correctly in one minute. The three levels are benchmark, strategic, and intensive. The benchmark reading level is the highest level. This is the minimum level of performance on a DIBELS test to be considered on track in oral reading fluency. The middle level is strategic. This is the minimum level of performance on a DIBELS test to be considered to have some risk for deficits in oral reading fluency. The lowest level is intensive. This is the minimum level of performance on a DIBELS test to be considered at risk for deficits in oral reading fluency (University of Oregon, n.d.b).

Table 7

Disaggregation of Qualitative Analysis by Grade Level, Gender, and Reading Level

Reading Level	Grade 3	Grade 4	Grade 5
Intensive Reader	4 boys 5 girls	4 boys 5 girls	5 boys 0 girls
Strategic Reader	5 boys 11 girls	2 boys 9 girls	4 boys 2 girls
Benchmark Reader	13 boys 13 girls	11 boys 10 girls	8 boys 10 girls

Impact of Oral Reading Fluency on Mathematics Performance

From the quantitative analysis, it was determined that oral reading fluency and mathematical problem solving are positively correlated. When a student's oral reading level increases, so does his or her mathematical problem-solving ability. Throughout the examination of the ISTEP+ mathematics test and Acuity Diagnostic mathematics test, the students' reading, vocabulary, and comprehension skills needed to correctly solve the given problems was heavily required. Those students who struggled to read fluently—which also impacts comprehension—also struggled to be successful on the constructed response portion of ISTEP+ mathematics test and also on any question on the Acuity Diagnostic test that required a lot of reading. The overall trend seemed to indicate that those students who read at the intensive level also scored lowest on the mathematics assessments.

When examining the ISTEP+ mathematics and Acuity Diagnostic assessments, scores and data were provided for a student's performance on language arts and math. Several comparisons were made between Language Arts and Mathematics scores. This portion of the analysis details these comparisons and includes tables to show data specific to the findings.

Overall DIBELS level and mathematics performance. The levels of passing indicated that students who read at a benchmark level had a higher percentage of students who were able to pass both the language arts and math portions of the ISTEP+ and Acuity Diagnostic assessments. Among those students reading at the benchmark level in third grade, 92% of boys and 100% of girls passed the ISTEP+ assessment and 92% of Bboys and 85% of girls passed the Acuity Diagnostic assessment. Among those students reading at the benchmark level in fourth grade, 91% of boys and 60% of girls passed the ISTEP+ assessment and 91% of boys and 70% of girls passed the Acuity Diagnostic assessment. Among those students reading at the benchmark level in fifth grade, 88% of boys and 90% of girls passed the ISTEP+ assessment and 88% of boys and 70% of girls passed the Acuity Diagnostic assessment. The same groups of students had the lowest percentage of students who did not pass both the language arts and math portions of the ISTEP+ and Acuity Diagnostic assessments. The opposite scenario was true for students reading at the intensive level. These students most often had the highest percentage of students not passing and the smallest percentage of students passing both tests. Among those students reading at the intensive level in third grade, 75% of boys and 20% of girls passed the ISTEP+ assessment and 75% of boys and 0% of girls passed the Acuity Diagnostic assessment. Among those students reading at the intensive level in fourth grade, 50% of boys and 20% of girls passed the ISTEP+ assessment and 74% of boys and 40% of girls passed the Acuity Diagnostic assessment. Among those students reading at the intensive level in fifth grade, 40% of boys passed the ISTEP+ assessment and 40% of boys passed the Acuity Diagnostic assessment. There were no female students in the intensive reading level for fifth grade. These percentages indicated that reading ability must have a relationship to mathematics ability.

Passing rates were usually positively correlated with reading levels; as students reading level increased, their ability to pass the mathematics portions of the ISTEP+ and Acuity Diagnostic tests also increased. When examining passing rates for those students at the benchmark reading level, these students also had the highest percentage of students who passed each assessment. In third grade, boys had 92% passing both ISTEP+ mathematics and Acuity Diagnostic mathematics. The female group had 100% passing ISTEP+ mathematics and 85% passing Acuity Diagnostic mathematics. For fourth grade students 91% of boys passed both assessments. Only 60% of the benchmark girls passed ISTEP+ mathematics; however, this percentage was still greater than the percentage of girls passing at the strategic and intensive reading levels. Seventy percent of the fourth grade girls passed Acuity mathematics diagnostic. Among fifth grade students at the benchmark reading level 88% of boys passed both assessments and 90% of girls passed ISTEP+ mathematics and 70% of girls passed Acuity mathematics diagnostic. As reading levels increased, rates of students passing the mathematics portion of ISTEP+ and Acuity Diagnostic tests also increased. As reading levels decreased, rates of students passing the mathematics portions of the ISTEP+ and Acuity Diagnostic tests also decreased. Tables 8 and 9 depict the number of students who passed each test. The data is disaggregated by grade level, gender, and reading level for each test.

Table 8

Number of Students Passing ISTEP+ Mathematics Assessment Test and DIBELS Level

Grade Level	Intensive	Strategic	Benchmark
3	3/4 (75%) M 1/5 (20%) F	4/5 (80%) M 5/11 (45%) F	12/13 (92%) M 13/13 (100%) F
4	2/4 (50%) M 1/5 (20%) F	2/2 (100%) M 4/9 (44%) F	10/11 (91%) M 6/10 (60%) F
5	2/5 (40%) M 0/0* (00%) F	4/4 (100%) M 2/2 (100%) F	7/8 (88%) M 9/10 (90%) F

Table 9

Acuity Diagnostic Mathematics Tests and DIBELS Level

Grade Level	Intensive	Strategic	Benchmark
3	3/4 (75%) M 0/5 (00%) F	3/5 (60%) M 5/11 (45%) F	12/13 (92%) M 11/13 (85%) F
4	3/4 (75%) M 2/5 (40%) F	1/2 (50%) M 5/9 (56%) F	10/11 (91%) M 7/10 (70%) F
5	2/5 (40%) M 0/0* (00%) F	3/4 (75%) M 1/2 (50%) F	7/8 (88%) M 7/10 (70%) F

Note. M = Boys; F = Girls; * There were no girls in the intensive reading level range.

Below level reading performance on ISTEP+ and mathematics performance.

Students are given a score on the ISTEP+ summary sheet reporting if they are below target or at or above target on specific Indiana academic standards. Three of the standards assessed on the ISTEP+ language arts test are vocabulary, nonfiction/information text, and literary text. These three standards would be indicative of how well students read and comprehend written text. These areas were examined and a comparison was made between those students who were below target on vocabulary, nonfiction/information text, and literary text and also did not pass the mathematics portion of the ISTEP+ assessment.

The relationship between reading fluency and mathematics problem solving is supported in Table 10. Among all grade levels and both gender groups reading at the benchmark level, there were no students who did not meet the ISTEP+ language arts target and also did not pass

ISTEP+ mathematics. The same was true for the strategic groups with the exception of third grade girls when four students (36%) who did not meet the language arts target and also did not pass mathematics. This was true because the majority of these students were at or above target in language arts and also passed mathematics. For strategic level boys in fifth grade, 100% of the boys at target in language arts also passed mathematics. Here, 36% of the girls who did not meet the language arts targets were also unable to pass the mathematics test. The percentages increase greatly when comparing those students reading at the intensive level. In third grade 25% of boys and 40% of girls who did not meet the language arts target also did not pass mathematics. In fourth grade 50% of boys and 20% of girls who did not meet the language arts target also did not pass mathematics. In fifth grade 60% of the boys who did not meet the language arts target also did not pass mathematics. There were no girls in the intensive reading level for fifth grade. Many of these students who were not at target for language arts did not pass mathematics. This finding supports that those students who struggle with reading will also struggle with mathematics.

Table 10

Percentages of Students Not Meeting Language Arts Target and Not Passing Math

Grade Level	Intensive	Strategic	Benchmark
3	1/4 (25%) M 2/5 (40%) F	0/5 (00%) M 4/11 (36%) F	0/13 (00%) M 0/13 (00%) F
4	2/4 (50%) M 1/5 (20%) F	0/2 (00%) M 0/9 (00%) F	0/11 (00%) M 0/10 (00%) F
5	3/5 (60%) M 0/0* (00%) F	0/4 (00%) M 0/2 (00%) F	0/8 (00%) M 0/10 (00%) F

Note. M = Boys; F = Girls; * There were no girls in the intensive reading level range.

Below level constructed response performance on ISTEP+ and mathematics performance. The ISTEP+ mathematics test is divided into two separate tests. The test used for the analysis is the first test given during the first testing window and contains constructed response items. During the second testing window, the multiple choice portion of the test is given. The ISTEP+ summary sheet does not provide a specific score for the multiple choice as it does for constructed response. When examining the mathematics scores, it was questioned how much of an impact the constructed response portion had on the overall score. Since each constructed response item was given a point value, those point values could be summed to gain a total point score for the extended response. The number of points earned by each student on his constructed response portion of the test was determined. A count was made of how many students earned less than 50% of the total points for the constructed response portion but earned an overall passing score on the ISTEP+ mathematics test.

The multiple choice portion of the test often contains questions with fewer words and sometimes uses questions that simply ask students to solve a computation problem. The readability and comprehension of this type of test compared to constructed response tests would seem to be lower. When looking at the Acuity Diagnostic mathematics test which, like ISTEP+, assesses Indiana academic standards, many of the questions included had fewer words to read than those questions found on ISTEP+. For intensive level readers, fewer words to read and comprehend may have yielded more correct answers.

When looking at these specific students, it was determined that for boys and girls, there were students in the group who did not score well on the constructed response, but were still able to pass the overall mathematics test. The only groups in which this was not true were certain fourth grade students. Each reading level was represented in this group including the intensive reading level boys (25%), the strategic reading level for boys (0%), and the benchmark reading level for girls (0%). The third grade test for multiple choice included mostly computation problems with a little amount of reading required to answer the questions. This assumption was made due to the third grade students having the highest overall percentage of students performing poorly on the constructed response, but still earning an overall passing score on the ISTEP+ mathematics assessment. Among the intensive reading level third graders, 25% of boys and 20% of girls were able to pass mathematics even though scoring fewer than 50% on the constructed response items. Among the strategic reading level third graders, 60% of boys and 36% of girls were able to pass mathematics even though scoring fewer than 50% on the constructed response items. Among the benchmark reading level third graders, 38% of boys and 69% of girls were able to pass mathematics even though scoring fewer than 50% on the constructed response items. Finally at least 20% or more of the students were able to perform successfully on the ISTEP+ mathematics assessment in its entirety due to the multiple choice questions when they performed poorly on the constructed response portion. Table 11 depicts the number and percentage of students by grade level and gender who passed the overall ISTEP+ mathematics test, but earned less that 50% of the points on the constructed response portion.

Table 11

Percentage of Students Who Scored Fewer Than 50% on ISTEP+ Constructed Response and Passed Mathematics

Grade Level	Intensive	Strategic	Benchmark
3	1/4 (25%) M 1/5 (20%) F	3/5 (60%) M 4/11 (36%) F	5/13 (38%) M 9/13 (69%) F
4	1/4 (25%) M 0/5 (00%) F	0/0 (00%) M 1/9 (11%) F	1/11 (00%) M 0/10 (00%) F
5	1/5 (20%) M 0/0* (00%) F	1/4 (25%) M 1/2 (50%) F	2/8 (25%) M 2/10 (20%) F

Note. M = Boys; F = Girls; * There were no girls in the intensive reading level range.

Levels of passing ISTEP+. For both tests, data were provided indicating which portions of the test students passed and did not pass. The assessments contained a language arts and mathematics portion. These levels included students who passed both portions, students who did not pass either portion, students who passed language arts and did not pass mathematics, and student who passed mathematics and did not pass language arts.

For third grade students, on ISTEP+ assessments boys and girls reading at the benchmark level had the highest percentage of students passing both the language arts and mathematics portions of the test, while the intensive level has the lowest percentage of boys and girls passing both the language arts and mathematics portions of the test. In contrast both genders from the intensive group had the highest percentage of students who did not pass the language arts and mathematics portions. Girls from the intensive reading level, both genders from the strategic reading level, and one male from the benchmark reading level passed language arts, but did not pass mathematics.

Among fourth grade students, the level of passing was similar to that of third grade. Girls from the benchmark reading level had the highest percentage pass (100% of third grade students and 60% of fourth grade students) and girls and male from the intensive level (third grade 50% of boys and 20% of girls, fourth grade 25% of boys and 20% of girls) had the lowest percentage pass both the language arts and mathematics portions of the test. Though the strategic reading level boys on had a passing rate of 100% for passing both portions of the test, there were only two boys in the subgroup. The benchmark reading level boys percentage of passing both portions of the test was also high 91% with only one member of the subgroup not passing both portions. With the exception of the intensive reading level boys, students were more likely to pass the language arts portion and not pass the mathematics portion. For Grade 3, 0% of boys and 18% of girls at the strategic reading level, and 8% of boys and 0% of girls at the benchmark reading level passed the language arts portion and did not pass the mathematics portion. For Grade 4, 0% of boys and 11% of girls at the strategic reading level and 0% for both boys and girls at the benchmark reading level passed the language arts portion and did not pass the mathematics portion. For Grade 5, 0% of boys and at the strategic reading level and 13% of boys and 10% of girls at the benchmark reading level passed the language arts portion and not the mathematics portion. Students were less likely to pass the mathematics portion and not pass the language arts portion. In Grade 3, 0% of boys and 9% of girls at the strategic reading level, and 0% of boys and 0% of girls at the benchmark reading level passed the mathematics portion and did not pass the language arts portion. For Grade 4, 0% of boys and girls at both the strategic reading level and the benchmark reading level passed the mathematics portion and did not pass the language arts portion. For Grade 5, 0% of boys and 100% of girls at the strategic reading level and 0% of boys and 10% of girls at the benchmark reading level passed mathematics and did not pass language arts. Fifth grade strategic girls were the exception with 100% of the group passing only the language arts portion of the test. When looking at the data from the fifth grade students, it must first be noted that there were no girls in the intensive reading level for ISTEP+ assessment. The fifth grade students' level of passing for both portions of the test was identical to that of ffourth grade with the exception of strategic level girls having the lowest percentage of students passing both portions (0%). It can be assumed that if there had been an intensive reading level group for girls, they would have been consistent with the other grade levels and had the lowest percentage of students passing both portions. Among fifth grade students, the pattern for passing one test and not the other is not consistent with grades three and four. Here intensive reading level boys and strategic reading level girls had a higher percentage passing the mathematics portion of the test and not passing the language arts portion with a rate of 20% and 100% respectively. However, the one male in the data group who did not pass both tests did follow the trend and pass language arts and not mathematics. The girls reading at the benchmark level had the 10% of students who passed one portion of the test and not the other.

The overall data indicated that most often those students reading at a benchmark level are most likely to pass both the language arts and mathematics portions of the test (in third grade 92% of boys and 100% of girls, in fourth grade 91% of boys and 60% of girls, in fifth grade 88%

of boys and 80% of girls) and also have the highest percentage of passing among the three reading levels. In contrast the intensive reading level students for boys and girls are most likely to have the lowest percentage passing both portions of the language arts and mathematics tests (in third grade 50% of boys and 20% of girls, in fourth grade 25% of boys and 20% of girls, in fifth grade 20% of boys. There were no female intensive reading level students in fifth grade) and actually had the highest percentage of students who did not pass either test (in third grade 25% of boys and 60% of girls, in fourth grade 50% of boys and 20% of girls, in fifth grade 60% of boys. There were no female intensive reading level students in fifth grade). Finally, among all three grade levels and within both genders, it was more likely for students to pass the language arts portion of the test and not pass the mathematics portions with the exception of fifth grade boys, 20% at the intensive reading level and 100% of girls at the strategic reading level passed mathematics and did not pass language arts. This trend is possibly due to the fact that mathematics requires reading skills along with mathematics skills to arrive at correct answers. Table 12 details the percentage of students passing and not passing each portion of the test divided into grade levels, reading levels, and gender groups.

Table 12

Percentage of Students at Each Passing Level on ISTEP+ Mathematics Assessment

	ISTEP+		
Grade and Level of Passing	Intensive	Strategic	Benchmark
Grade 3			
Passed both portions	2/4 (50%) M	4/5 (80%) M	12/13 (92%) M
	1/5 (20%) F	4/11 (36%) F	12/12 (100%) F
Did not pass either portion	1/4 (25%) M	0/5 (00%) M	0/13 (00%) M
	3/5 (60%) F	4/11 (36%) F	0/12 (00%) F
Passed reading/did not pass math	0/4 (00%) M	1/5 (20%) M	1/13 (8%) M
	1/5 (20%) F	2/11 (18%) F	0/12 (00%) F
Passed math/did not pass reading	1/4 (25%) M	0/5 (00%) M	0/12 (00%) M
	0/5 (00%) F	1/11 (9%) F	0/12 (00%) F
Grade 4			
Passed both portions	1/4 (25%) M	2/2 (100%) M	10/11 (91%) M
	1/5 (20%) F	4/9 (44%) F	6/10 (60%) F
Did not pass either portion	2/4 (50%) M	0/2 (00%) M	0/11 (00%) M
	1/5 (20%) F	1/9 (11%) F	0/10 (00%) F
Passed reading/did not pass math	2/4 (50%) M	0/2 (00%) M	0/11 (00%) M
	1/5 (20%) F	1/9 (11%) F	0/10 (00%) F
Passed math/did not pass reading	1/4 (25%) M	0/2 (00%) M	0/11 (00%) M
	0/5 (00%) F	0/9 (00%) F	0/10 (00%) F
Grade 5			
Passed both portions	1/5 (20%) M	4/4 (100%) M	7/8 (88%) M
	F*	0/2 (00%) F	8/10 (80%) F
Did not pass either portion	3/5 (60%) M	0/4 (00%) M	0/8 (00%) M
	F*	0/2 (00%) F	0/10 (00%) F
Passed reading/did not pass math	0/5 (00%) M	0/4 (00%) M	1/8 (13%) M
	F*	0/2 (00%) F	1/10 (10%) F
Passed math/did not pass reading	1/5 (20%) M	0/4 (00%) M	0/8 (00%) M
	F*	2/2 (100%) F	1/10 (10%) F

Note. *There were no girls in the intensive reading level range.

Levels of passing Acuity Diagnostic Mathematics Assessment. For third grade students, boys and girls reading at the benchmark level had the highest percentage of students passing both the language arts and mathematics portions of the test, while the intensive level had the lowest percentage of boys and girls passing both the language arts and mathematics portions of the test. For third grade boys 77% passed both portions and for girls 83% passed both portions. For both male and female students reading at the intensive level, 0% passed both portions of the test. In contrast both genders from the intensive group had the highest percentage of students who did not pass the language arts and mathematics portions (25% of boys and 60% of girls). On Acuity Diagnostic, more groups, including intensive reading level boys and strategic reading level boys and girls were more likely to pass mathematics and not pass language arts (75% for third grade, 50% for fourth grade, and 20% for fifth grade). Though intensive and benchmark reading level girls had higher percentages passing language arts and not passing mathematics. This equaled 40% of intensive reading level and 17% of benchmark reading level third grade students, 20% of intensive reading level and 10% of benchmark reading level fourth grade students, and 30% of benchmark reading level fifth grade students.

Among fourth grade students, the level of passing was similar to that of third grade. As predicted, the male and female benchmark reading levels had the highest percentage passing both assessments (77% of male and 83% of female third grade students, 91% of male and 70% of female fourth grade students) while the boys and girls at the intensive reading level had the highest percentage of students not passing either assessment (25% of male and 60% of female third grade students and 25% of male and 40% of female fourth grade students). Students were more likely to pass the language arts portion and not the mathematics portion as opposed to not passing language arts and passing mathematics. However, intensive reading level girls in fourth grade had 20% percent of students passing one assessment and not the other.

Similar patterns continued for fifth grade students. Benchmark reading level boys and girls had the highest percentage passing both assessments (88% of boys and 70% of girls) while the intensive reading level boys (40%) had the lowest percentage passing. When looking at the percentage of boys and girls at each reading level who passed one portion of the test and not the other portion, fifth grade students remained consistent having a higher percentage of students passing language arts and not passing mathematics with 25% of boys and 50% of girls at the strategic reading level, 13% of boys and 30% of girls at the benchmark reading level. However, the intensive reading level boys (20%) tied with one student in the overall group passing language arts and not passing mathematics and one student in the overall group passing mathematics and not passing language arts.

When the data were examined by grade level, the prediction that benchmark level male and female readers would outperform intensive level male and female readers could be made. It was also found, among all three grade levels and within both genders, it was more likely for students to pass the language arts portion of the test and not pass the mathematics portions. This trend was possibly due to the fact that mathematics required reading skills along with mathematics skills to arrive at correct answers.

When the data were combined and examined, it was found that male and female students reading at a benchmark level had the highest percentage of students who passed both the language arts and mathematics portions of the test. This equaled 84% of boys and 75% of girls. In contrast the intensive reading level students for boys and girls had the lowest percentage of students who passed both portions of the language arts and mathematics tests (15% of boys and 10% of girls) and actually had the highest percentage of students who did not pass either test (31% of males and 50% of females). When all the data were combined, it was determined that benchmark and intensive reading level girls were more likely to pass language arts and not pass math. Intensive reading level boys were more likely to pass mathematics than language arts with a rate of almost 50%. Finally, 20% of strategic reading level girls passed mathematics and not passing language arts. Table 13 details the percentage of students passing and not passing each portion of the test divided into grade levels, reading levels, and gender groups.

Table 13

Percentage of Students at Each Passing Level on Acuity Diagnostic Assessment

	Acuity		
Grade and Level of Passing	Intensive	Strategic	Benchmark
Grade 3			
Passed both portions	0/4 (00%) M	1/5 (20%) M	10/13 (77%) M
	0/5 (00%) F	2/11 (18%) F	10/12 (83%) F
Did not pass either portion	1/4 (25%) M	2/5 (40%) M	1/13 (8%) M
	3/5 (60%) F	5/11 (46%) F	0/12 (00%) F
Passed reading/did not pass math	0/4(00%) M	0/5 (00%) M	0/13 (00%) M
	2/5 (40%) F	1/11 (9%) F	2/12 (17%) F
Passed math/did not pass reading	3/4 (75%) M	2/5 (40%) M	2/12 (17%) M
	0/5 (00%) F	3/11 (27%) F	0/12 (00%) F
Grade 4			
Passed both portions	1/4 (25%) M	1/2 (50%) M	10/11 (91) M
	1/5 (20%) F	5/9 (56%) F	7/10 (70%) F
Did not pass either portion	1/4 (25%) M	0/2 (00%) M	0/11(00%) M
	2/5 (40%) F	4/9 (44%) F	2/10 (20%) F
Passed reading/did not pass math	0/4 (00%) M	1/2 (50%) M	1/11 (9) M
	1/5 (20%) F	0/9 (00%) F	1/10 (10%) F
Passed math/did not pass reading	2/4 (50%) M	0/2 (00%) M	0/11 (00%) M
	1/5 (20%) F	0/9 (00%) F	0/10 (00%) F

Table 13 (continued)

Percentage of Students at Each Passing Level on Acuity Diagnostic Assessment

	Acuity		
Grade and Level of Passing	Intensive	Strategic	Benchmark
Grade 5			
Passed both portions	1/5 (20%) M	3/4 (75%) M	7/8 (88%) M
	F*	0/2 (00%) F	7/10 (70%) F
Did not pass either portion	2/5 (40%) M	0/4 (00%) M	0/8 (00%) M
	F*	0/2 (00%) F	0/10 (00%) F
Passed reading/did not pass math	1/5 (20%) M	1/4 (25%) M	1/8 (13%) M
	F*	1/2 (50%) F	3/10 (30%) F
Passed math/did not pass reading	1/5 (20%) M	0/4 (00%) M	0/8 (00%) M
	F*	1/2 (50%) F	0/10 (00%) F

Note. *There were no girls in the intensive reading level range.

Number of words per question. Research Question 9 asked: Among third, fourth, and fifth grade students, what errors in mathematical problem solving ability are related to the amount of reading of text in the problem? Research Question 10 asked: What differences exist between genders in errors in mathematical problem solving ability related to the amount of reading of the text in the problem?

A count was made to determine how many words were in each question on the mathematics assessments. The words counted did not include numbers appearing in numeric form, but did include numbers in their written form. One thing to consider when looking at the number of words in a problem is the oral reading fluency levels of students. The number of words per minute a student can read is one way to evaluate his or her oral reading fluency. Students reading at intensive and strategic reading levels are considered not to be fluent. The number of words students were required to read would take different amounts of time for students at differing oral reading fluency levels. The average number of words found on the ISTEP+ ,athematics assessment was 29.5 words for third grade, 56.5 words for fourth grade, and 58 words for fifth grade. Students in third grade who were considered at the intensive reading level read less than 73 words per minute. For a student who only reads around 30 words a minute, it would have taken him or her that long to just read the words in the question. Most questions required rereading for comprehension and then still more time to work through the problem and arrive at an answer. The number of words a student had to read for each question may have impacted his or her ability to complete the problem.

A range of words and levels for these ranges was established. This process was done by starting with the lowest number of words on a question on the assessment and the highest number of words on a question on the assessment and then developing a range between the two numbers. The ranges created were low level, medium level, and high level. Low, medium, and high were reflective of the number of words in each level. For the third grade ISTEP+ mathematical assessment, low level was 13-24 words, medium level was 25-36 words, and high level was 37-49 words. For the fourth grade ISTEP+ mathematical assessment, low level was 32-48 words, medium level was 49-65 words, and high level was 66-82 words. For the fifth grade ISTEP+ mathematical assessment, low level was 36-50 words, medium level was 51-65 words, and high level was 66-79 words. For the third grade Acuity Diagnostic mathematical assessment, low level was 4-15 words, medium level was 16-27 words, and high level was 28-40 words. For the fourth grade Acuity Diagnostic mathematical assessment, low level was 1-13 words, medium level was 14-28 words, and high level was 29-42 words. For the fifth grade Acuity Diagnostic mathematical assessment, low level was 4-18 words, medium level was 19-33 words, and high level was 34-46 words. Most often the questions on both the ISTEP+

mathematics and Acuity Diagnostic mathematics assessments were considered having a low level of words. Although that could have been as low as 13 words in the question, it could have been as high as 50 words in the question. The medium level of words was only the level with the highest percentage of questions on one assessment, third grade Acuity Diagnostic mathematics. The high level word questions were the least common type used, but when questions were in the high level, they could have had as many as 82 words in the question. This would have been a large number of words to read and comprehend in order to correctly answer a mathematics questions. Since some questions on the ISTEP+ mathematics assessment have multiple parts, these large numbers of words may have required rereading several times in order to understand how to solve the mathematics problem. Tables 14 and 15 reflect how many questions for both assessments contained each level of words.

Table 14

Number of Words Per Question (ISTEP+)

Grade Level	Average # of Words	# of Words in Each Level	ISTEP+ # of Questions at Each Level
3	29.5	Low 13-24	5/7 (71%)
		Medium 25-36	0/7 (00%)
		High 37-49	3/7 (43%)
4	56.5	Low 32-48	4/8 (50%)
		Medium 49-65	1/8 (13%)
		High 66-82	3/8 (38%)
5	58.0	Low 36-50	3/6 (50%)
		Medium 51-65	2/6 (33%)
		High 66-79	1/6 (17%)

Table 15

Number of Words Per Question (Acuity Diagnostic)

Grade Level	Average # of Words	# of Words in Each Level	ISTEP+ # of Questions at Each Level
3	36	Low 4-15	11/30 (37%)
		Medium 16-27	12/30 (40%)
		High 28-40	7/30 (23%)
4	14	Low 1-13	17/30 (57%)
		Medium 14-28	9/30 (30%)
		High 29-42	4/30 (13%)
5	15	Low 4-18	23/30 (77%)
		Medium 19-33	5/30 (17%)
		High 34-46	2/30 (6%)

When looking at the number of words per question, an analysis was completed to determine how many students incorrectly answered questions at the low, medium, and high word levels. These data were sorted by grade, gender, and reading fluency level. Out of all three grade levels and on both assessments, 14 groups of the intensive readers had the highest number of incorrect answers. For questions with a low number of words this included fourth grade girls (90% for ISTEP+ and 62% for Acuity), fifth grade boys (93% for ISTEP+ and 42% for Acuity). For questions with a medium number of words this included third grade girls (60% for Acuity), fourth grade girls (42% for Acuity), fifth grade boys (60% for ISTEP+ and 48% for Acuity). For questions with a high number of words this included third grade boys (58% for ISTEP+), third grade girls (67% for ISTEP+ and 69% for Acuity), fourth grade boys (75% for ISTEP+ and 25% for Acuity), and fifth grade boys (40% for Acuity). When examining the intensive level groups, they most often missed the questions considered to have a high level of words. For third grade

ISTEP+ 58% of boys and 67% of girls and for Acuity the intensive boys did not have the highest percentage missing questions among reading level, though girls did at 69%. For fourth grade ISTEP+ 75% of boys and for Acuity 25% of boys. The female intensive reading level group did not have the highest percentage of students incorrectly answering questions at the high word level. For fifth grade ISTEP+ boys did not have the highest percentage of students missing questions with a high number of words. For Acuity 40% of boys missed questions with high numbers of words. There were no fifth grade girls reading at the intensive level. In two cases, the intensive reading group and strategic reading groups were tied for having the highest number of students incorrectly answering questions from high word level groups. The tied groups included fourth grade girls (93% for ISTEP+) and fifth grade boys (100% for ISTEP+). The strategic girls in fifth grade (100%) had the most incorrect answers for high levels or words. This should be noted because the intensive reading group is the second lowest and in fifth grade there is no female intensive reading group. The benchmark girls had the lowest number of incorrect answers on all levels of words on both assessments in each grade level with the exception of the fifth grade high word level groups. In this group, the benchmark girls tied with the strategic girls. Among third grade girls on ISTEP+ 55% and on Acuity 33% for low number of words, on ISTEP+ there were no medium level word questions and on Acuity 28% for medium number of words, on ISTEP+ 46% and on Acuity 36% for high number of words. Among fourth grade Girls on ISTEP+ 55% and on Acuity 40% for low number of words, on ISTEP+ 50% and on Acuity 23% for medium number of words, on ISTEP+ 50% and on Acuity 25% for high number of words. Among fifth grade girls on ISTEP+ 67% and on Acuity 25% for low number of words, on ISTEP+ 35% and on Acuity 38% for medium number of words, on ISTEP+ 100% and on Acuity 65% for high number of words. This data show that the lower reading fluency levels more often incorrectly answer questions of all three word levels. Frequently the benchmark boys had the fewest number of students incorrectly answering questions at all three word levels. The data for boys who missed the fewest number of questions dependent on level of words. For males on the Acuity assessment, 33% missed questions with low number of words, 30% missed questions for medium number of words, and 18% missed questions for high number of words. Among fourth grade boys on Acuity assessment, 29% missed questions for low number of words, 16% missed questions for medium number of words, and 52% missed questions for high number of words. On ISTEP+ 52% missed questions for high number of words. Among fifth grade boys on ISTEP+, 63% missed questions for low number of words, 44% missed questions for medium number of words, and 88% missed questions for high number of words. On Acuity assessment, 43% missed questions for medium number of words and 31% missed questions for high number of words. When they did not have the fewest, the strategic boys had the fewest number of students incorrectly answering the questions based on word level. The male strategic groups outperforming the male benchmark groups included third grade ISTEP+ for high number of words per question (20%), fourth grade ISTEP+ for low number of words per question (50%), fourth grade ISTEP+ for medium number of words per question (50%), fourth grade Acuity for high number of questions (13%), fifth grade ISTEP+ (42%) and Acuity (25%) for low number of words per questions, and fifth grade ISTEP+ (25%) for medium number of words per question. Most often when the strategic reading level reading level boys outperformed the benchmark reading level boys, it was on a problem considered to have a low level of words. In only two instances did the strategic reading level boys outperform the benchmark reading level boys on questions containing high word levels. These data again support that the benchmark reading level students who have the highest fluency tend to outperform the intensive reading level students who have the lowest fluency on mathematics assessments. The more words that had to be read, the more frequent the incorrect responses. Tables 16 and 17 contain the percentages of students incorrectly answering mathematics questions based on the number of words in each question.

Table 16

Ratio of Students Incorrectly Answering Problems Based on Number of Words in the Problem (ISTEP+)

Level of Words Per Question	Intensive	Strategic	Benchmark
Grade 3 – Low	9/20 (45%) M 17/25 (68%) F	16/25 (64%) M 41/55 (75%) F	33/65 (51%) M 36/65 (55%) F
Grade 3 – Medium	*	*	*
Grade 3 – High	7/12 (58%) M 10/15 (67%) F	7/35 (20%) M 19/33 (58%) F	14/39 (36%) M 18/39 (46%) F
Grade 4 – Low	11/16 (69%) M 18/20 (90%) F	4/8 (50%) M 31/36 (86%) F	32/44 (73%) M 22/40 (55%) F
Grade 4 – Medium	3/4 (75%) M 4/5 (80%) F	1/2 (50%) M 8/9 (89%) F	9/11 (82%) M 5/10 (50%) F
Grade 4 – High	14/15 (93%) M 9/12 (75%) F	4/6 (67%) M 25/27 93%) F	17/33 (52%) M 15/30 (50%) F
Grade 5 – Low	14/15 (93%) M **	5/12 (42%) M 6/6 (100%) F	15/24 (63%) M 20/30 (67%) F
Grade 5 – Medium	6/10 (60%) M **	2/8 (25%) M 3/4 (75%) F	7/16 (44%) M 7/20 (35%) F
Grade 5 – High	5/5 (100%) M **	4/4 (100%) M 2/2 (100%) F	7/8 (88%) M 9/9 (100%) F

Note. The first number indicates that number of students who missed the question. The second number is the number of total responses. * indicates no questions with medium word level. ** indicates no girls in the intensive reading group.

Table 17

Ratio of Students Incorrectly Answering Problems Based on Number of Words in the Problem (Acuity Diagnostics)

Level of Words Per Question	Intensive	Strategic	Benchmark
Grade 3 – Low	16/44 (36%) M 35/55 (64%) F	25/55 (45%) M 54/121 (45%) F	47/143 (33%) M 47/143 (33%) F
Grade 3 – Medium	22/48 (46%) M 36/60 (60%) F	32/60 (53%) M 69/132 (52%) F	47/156 (30%) M 43/156 (28%) F
Grade 3 – High	6/28 (21%) M 24/35 (69%) F	12/35 (34%) M 29/77 (38%) F	16/91 (36%) M 33/91 (36%) F
Grade 4 – Low	23/68 (34%) M 53/85 (62%) F	19/34 (56%) M 64/153 (42%) F	55/187 (29%) M 68/170 (40%) F
Grade 4 – Medium	13/36 (36%) M 19/45 (42%) F	8/18 (44%) M 23/81 (28%) F	16/99 (16%) M 21/90 (23%) F
Grade 4 – High	4/16 (25%) M 6/20 (30%) F	1/8 (13%) M 19/36 (53%) F	8/44 (18%) M 10/40 (250%) F
Grade 5 – Low	48/115 (42%) M **	23/92 (42%) M 25/46 (100%) F	58/184 (32%) M 57/230 (25%) F
Grade 5 – Medium	12/25 (48%) M **	9/20 (45%) M 4/10 (40%) F	17/40 (43%) M 19/50 (38%) F
Grade 5 – High	4/10 (40%) M **	3/8 (38%) M 3/4 (75%) F	5/16 (31%) M 13/20 (65%) F

Note. The first number indicates that number of students who missed the question. The second number is the number of total responses. ** indicates no girls in the intensive reading group.

Error patterns. Research Question 5 asked: Among third, fourth, and fifth students, what common error patterns related to reading fluency can be detected on ISTEP+ mathematical constructed response and Acuity Diagnostic assessment? Research Question 6 asked: What differences exist between genders in common error patterns related to reading fluency on the ISTEP+ mathematical constructed response and Acuity Diagnostic assessment?

An examination of the mathematical constructed response portion of the ISTEP+ test and the Acuity mathematics diagnostics test was performed. For the ISTEP+ test, actual student work and answers were available for review. For the Acuity mathematics diagnostic test, a copy of the test questions along with answers given by students was available. These two assessments were studied and analyzed to try to find error patterns related to fluency. Several common error patterns were consistent between both tests and found across gender and grade level. These errors included use of mathematical vocabulary words, language use in the problem included unfamiliar scenarios, use of ethnic or unfamiliar names, nonstandard terms for computation and wording of the problem, and multiple meaning words within the questions. These errors were analyzed for whole group, boys, and girls by grade level and reading fluency level.

Mathematical vocabulary. Research Question 7 asked: Among third, fourth, and fifth grade students, what errors in mathematical problem solving ability are related to mathematical vocabulary knowledge? Research Question 8 asked: What differences exist between genders in errors in mathematical problem solving ability related to mathematical vocabulary knowledge?

The most common error pattern determined was due to mathematics vocabulary. Words that would be considered Tier 3 by Beck et al. (2002) were those words that are specific to content areas such as words found specifically in a mathematics or science context. Those Tier 3 type words were found on both tests and overwhelmingly on the Acuity Diagnostic test. Examples of these words were difference, least, odd, even, expression, and equivalent. A complete list of the words fitting this description is available in Appendix B. Questions containing mathematic vocabulary words that students would need to know the definition to be able to solve the problem constituted the majority of both assessments are presented in Table 18.

Table 18

Ratio of Questions on Assessments Containing Specific Math Vocabulary

Grade Level	ISTEP+ Mathematics	Acuity Diagnostic Mathematics
3	4/7 (57%)	24/30 (80%)
4	6/8 (75%)	28/30 (93%)
5	5/6 (83%)	28/30 (93%)

It is a necessary component of a mathematics test to contain mathematics vocabulary words. The data in Table 17 indicated that a student can expect more than half, and in some cases almost all, of the questions to contain these types of words. Each question on the ISTEP+ mathematics constructed response and the Acuity Diagnostic test that contains problem solving questions was evaluated for containing or not containing mathematics vocabulary words. It should be noted, that for third and fifth grade Acuity Diagnostic test, two of the questions that covered the Indiana academic standard of problem solving did not contain words considered specific mathematics vocabulary. Overall, in both groups, the intensive reading level students and stategic reading level students had a higher percentage incorrectly answering questions containing mathematics vocabulary. Among third grade students in the intensive reading level on ISTEP+ 75% of boys and 90% of girls and on Acuity 40% of boys and 66% of girls missed questions containing mathematics vocabulary. Among third grade students in the strategic reading level on ISTEP+ 85% of boys and 93% of girls and on Acuity 47% of boys and 51% of girls missed questions containing mathematics vocabulary. Among fourth grade students in the intensive reading level on ISTEP+ 75% of boys and 47% of girls and on Acuity 34% of boys and 51% of girls missed questions containing mathematics vocabulary. The fourth grade boys are the exception with benchmark level boys incorreclty answering more questions than strategic reading level boys on ISTEP+ (60%). However, on Acuity 32% of boys in the benchmark reading level missed questions containing mathematics vocabulary and this percentage was the lowest among the three reading levels. Among fifth grade students in the intensive reading level, on ISTEP+ 88% of boys and on Acuity 47% of boys missed questions containing mathematics vocabulary. There were no fifth grade girls in the intensive reading level. Among fifth grade students in the strategic reading level, on ISTEP+ 50% of boys and 80% of girls and on Acuity 38% of boys and 54% of girls missed questions containing mathematics vocabulary. For all reading levels the male group most often outperformed the female group. This indicated that female students in all reading levels struggled more with mathematics vocabulary than male students. With questions on assessments containing mathematics vocabulary at least 57% and up to 93% of the time, students who were unfamiliar with the vocabulary words and their defintions would have had much difficulty. Table 18 presented the number of questions on each assessment identified as containing mathematics vocabulary. Table 19 contains data reflecting the ratio of students who incorrectly answered questions with specific mathematics vocabulary.

Table 19

Ratio of Student Incorrectly Answering Questions With Specific Mathematics Vocabulary

Grade Level/Test	Intensive	Strategic	Benchmark
Grade 3 ISTEP+	12/16 (75%) M 18/20 (90%) F	17/20 (85%) M 41/44 (93%) F	37/52 (71%) M 3752 (72%) F
Grade 3 Acuity Diagnostic	38/96 (40%) M 79/120 (66%) F	56/120 (47%) M 134/264 (51%) F	93/312 (30%) M 113/312 (36%) F
Grade 4 ISTEP+	18/24 (75%) M 28/60 (47%) F	7/12 (58%) M 45/54 (83%) F	40/66 (60%) M 31/60 (52%) F
Grade 4 Acuity Diagnostic	38/112 (34%) M 72/140 (51%) F	30/56 (54%) M 108/252 (43%) F	85/264 (32%) M 95/240 (40%) F
Grade 5 ISTEP+	22/25 (88%) M F*	10/20 (50%) M 8/10 (80%) F	24/40 (60%) M 36/50 (72%) F
Grade 5 Acuity Diagnostic	66/140 (47%) M F*	43/112 (38%) M 30/56 (54%) F	78/224 (35%) M 84/280 (30%) F

Note. The first number indicates the number of students who missed the question; the second number is total number of responses.

Many mathematics vocabulary terms correspond with each other, but tend to have opposite operations. Examples of this type of terminology found on the assessment were odd and even, least and greatest, and sum and difference. Some vocabulary words correspond with each other though they are not necessarily opposite operations. These are terms such as area and perimeter or symmetry and congruency. Often when a student incorrectly answers a question asking to figure area, it is because he or she has figured perimeter. When examining the assessments, many students gave incorrect answers that I determined was the opposite of what the question asked. When a student answered with an odd number to a question asking for an even number or found perimeter instead of area, it showed that the student understood some part of the concept but did not have a complete understanding of the word. Beck et al. (2002) determined students have different levels of knowing a word. Among these levels is just recognizing the word all the way to a conceptual understanding of the word that allows them to use the word and apply it in multiple situations. Students' confusion of words that are related shows some knowing of the word but a lack of total comprehension.

Overall there were 11 questions on all three of the assessments where students used the opposite mathematics term from the one that was needed. These students gave incorrect answers that indicated they were familiar with the mathematics terminology but used the opposite meaning of the given terminology. Both gender groups in the intensive reading level had the highest percentage of incorrect answers on questions with mathematics terms that had corresponding terms with the opposite meaning. The Male group had 43% of students answering incorrectly and the Female group had 37% answering incorrectly. The female benchmark reading level groups for all grades had the fewest number of errors among girls (21%) and the second fewest number of errors overall. The Boys benchmark reading level contained the second fewest incorrect answers and was only one percentage point different from strategic boys. These data indicated that the students with the lowest reading fluency levels most often incorrectly answer questions containing mathematics terminology with corresponding opposite terminology. Students who are struggling with reading fluency often struggle with word recall and comprehension. The skill needed to solve mathematics problems that require an understanding of words, such as *odd*, that have an opposite mathematics term, *even*, may be the same as some of the skills needed to read fluently, which include word recognition and recall. Table 20 shows the number of students in each reading level missing words with mathematics terminology.

Table 20

Ratio of Students Incorrectly Using Mathematics Terminology

Intensive	Strategic	Benchmark
17/40 (43%) M	5/33 (15%) M	18/111 (16%) M
13/35 (37%) F	19/73 (26%) F	24/113 (21%) F

Note. The first number indicates that number of students who missed the question; the second number is the number of total responses.

Language within problems. When examining the ISTEP+ Mathematics and Acuity Diagnostic Mathematics assessments, it was noted that the wording of some problems may have caused difficulty. Examples of this would be word problems containing unfamiliar scenarios, ethnic names of people and names of unknown places, and nonstandard terms for computation and specific wording of the problem. These examples were found throughout the three grade levels and on both assessments. When fluent reading is not achievable due to the language of the problem, comprehension of the problem can be limited, which could be a cause of error in mathematical problem solving among students especially those whose oral reading fluency scores fall in the intensive range.

Unfamiliar scenarios. High poverty schools such as the one used for this study enroll students with limited experiences. Mathematical problems focused on traveling, which included the names of unfamiliar places, buying or selling goods not commonly purchased by those in poverty such as plane tickets, or hands-on projects such as sewing or building fences. Mathematics problems such as these lend themselves to confusion and students may not be able to comprehend the context well enough to sort through to the actual mathematics problems.

Table 21 shows the combined number of questions on the two assessments that contained what could be unfamiliar scenarios.

Table 21

Ratio of Questions Containing Unfamiliar Scenarios

Grade Level	Number of Questions
3rd grade	7/37 (19%)
4th grade	3/38 (8%)
5th grade	6/36 (17%)

The percentage of students missing these questions was high in most grades and reading levels for each of the gender groups. In 10 out of the 17 groups, over 50% of the students in the groups missed questions with unfamiliar context and four more groups were close to the 50% mark with two at 49%, one at 48%, and one at 47%. Both the intensive and strategic reading groups had over 40% of the students in the groups and among three of those groups 80% or more students unable to correctly answer the identified questions. Even within the benchmark reading groups, with the exception of 4th grade boys, the percentages were high. These overall percentages indicated that unfamiliar text had a large impact on students' success on mathematical problem solving. Table 22 shows the number of test questions containing what I deemed unfamiliar situations and the data for students who answered the problem incorrectly.

Table 22

Ratio of Students Who Incorrectly Answered Question with Unfamiliar Context

Grade Level	Intensive	Strategic	Benchmark
3rd grade	15/28 (54%) M 31/35 (89%) F	17/35 (49%) M 51/77 (66%) F	45/91 (49%) M 44/91 (48%) F
4th grade	5/12 (42%) M 12/15 (80%) F	5/6 (83%) M 15/27 (56%) F	11/33 (33%) M 14/30 (47%) F
5th grade	20/30 (67%) M F*	11/24 (46%) M 8/12 (67%) F	24/48 (50%) M 34/48 (71%) F

Note. The first number indicates that number of students who missed the question; the second number is the number of total responses.

Use of ethnic or uncommon names. Test questions often use ethnically derived names or uncommon names for the people who are part of the mathematic problem. Often the names are just uncommon or not names students have heard because they know other students with that same name. A review of the list of the 100 most popular names given to babies over the past 100 years contained very few of the names found in the assessments (Social Security online, n.d.). It is possible that students do not recognizing these names and it causes confusion when trying to sort out the needed and important details of a mathematics problem. Students may confuse the name for information that is pertinent to the problem. They may think the name is a mathematics term with which they are unfamiliar. When reviewing test questions for ethnic or unfamiliar names, it should be noted that four of the questions containing unfamiliar names were also questions containing an unfamiliar context. Third and fourth grade each had one question fitting both categories and fifth grade had two questions. Though many more questions contained names, Table 23 shows the number of questions containing names deemed ethnic or unfamiliar.

Table 23

Amount of Questions Containing Ethnic or Unfamiliar Names

Grade Level	Number of Questions
3	4/37 (11%)
4	3/38 (8%)
5	4/36 (11%)

There were no specific patterns for the data related to the number of students incorrectly answering questions with ethnic or unfamiliar names. The benchmark reading levels for third (21% of boys and 37% of girls) and fourth grade (18% of boys and 20% of girls) and fifth grade girls (38%) has the lowest percentage of students incorrectly answering those questions. This could be an indication that those students were able to compute the mathematics problem correctly regardless of the knowing or not knowing the name. The intensive groups had the highest percentages of students incorrectly answering the questions with 38% of third grade boys, 55% of third grade girls, and 33% of fourth grade girls, with the exception of fourth grade boys who were the same as the strategic level boys (33%), and fifth grade boys who outperformed the benchmark level boys (37%). Girls more often missed these questions than boys. This may have occurred because boys tend not to focus on name pronunciation and disregarded the unfamiliar name while girls were distracted by the unfamiliar name. Finally, in many classrooms, teachers have begun teaching students to replace an unfamiliar name with a name they know. If students in the testing groups were using this strategy, it possibly lowered the number of students incorrectly answering questions containing ethnic or unfamiliar names.

Table 24 displays how many students at each grade level and reading level divided by gender incorrectly answer questions with ethnic or unfamiliar names.

Table 24

Ratio of Students Who Incorrectly Answered Questions with Ethnic or Unfamiliar Names

Grade Level	Intensive	Strategic	Benchmark
3	6/16 (38%) M	5/20 (25%) M	11/52 (21%) M
	11/20 (55%) F	17/44 (39%) F	19/52 (37%) F
4	4/12 (33%) M	2/6 (33%) M	6/33 (18%) M
	5/15 (33%) F	5/27 (19%) F	6/30 (20%) F
5	11/30 (37%) M	8/24 (33%) M	20/48 (42%) M
	F*	7/12 (58%) F	18/48 (38%) F

Note. The first number indicates that number of students who missed the question; the second number is the number of total responses.

Nonstandard terms for computation and wording of the problem. As discussed earlier the majority of the mathematics problems contained mathematics vocabulary. Some questions found on the assessment contained words that I had labeled nonstandard. Another observation was that the questions were worded in a way that seemed to make the questions more difficult to understand what the question was asking. The wording of these questions did not seem to be reflective of the wording used in textbooks or by educators. Terms such as *how many in all, how many were left, find the total, find the difference*, or *equal groups* are found in textbooks and used by educators. Discrepancies in wording or the use of words to indicate a math process that are not considered math terms were common on one assessment. Instead of using mathematics terminology such as *added*, the questions used the word *got* or *in addition to*. A student would have to have known that *in addition to* means to *add*. Instead of using *subtracted*, the questions used *gave*. Here a student would have to process that *gave* means to *subtract*. The use of the word *contained* again assumes the student understands the meaning of *contained* and can apply that meaning to mathematics. Two of the most common terms used in mathematics problem solving are *how many in all* and *how much is left*. Questions requiring this type of computation may have used *how many are there, how much was collected* for addition, or *how much is remaining*, *how much was removed*, or *shortened* for *how much was left*. When asking for multiple answers, the question asked for *all the possible combinations* when *list all the ways* might have been more easily understood. The assessments for each grade level had questions in which the students had to round a number to a specific place value. The majority of these questions were worded in this way: "*What is* (a number) *rounded to the nearest* (place value)? Questions asking students to round are most often stated, "*Round* (a number) *to the nearest* (place value). The wording of at least 20 of the problems made them more difficult to understand. Table 25 shows the number of questions per grade level that contained nonstandard mathematics terminology and difficult wording.

Table 25

Number of Questions Containing Nonstandard Math Terms and Difficult Wording

Grade Level	Number of Questions
3	6/37 (16%)
4	7/38 (18%)
5	7/36 (19%)

When examining the data related to nonstandard mathematics terms and words, again the benchmark reading level students in all grades and both genders had the lowest percentage of students answering incorrectly. In third grade both gender groups for benchmark reading level contained 78 students. Of these students 19 (25%) of boys and 27 (35%) of girls answered questions with nonstandard mathematics terms and words incorrectly. In fourth grade 21% of boys and 41% of girls answer questions with nonstandard mathematics terms or words incorrectly. In fifth grade 25% of boys and 30% of girls answered questions with nonstandard mathematics terms or words incorrectly. The strategic reading level students for all groups, with the exception of third grade boys, also had fewer students answering incorrectly than those students in the intensive group: 35% for third grade girls, 23% for fourth grade goys, 54% for fourth grade girls, 39% for fifth grade boys, and 79% for fifth grade girls. It should be noted that the boys in the intensive group scoring incorrectly was only one percentage point lower than those boys in the strategic group. The data also showed that five of the groups had over 50% of the students incorrectly answering these types of questions. These groups included third grade intensive reading level girls (67%), fourth grade intensive and strategic level girls (57% and 54%), fifth grade intensive reading level boys (57%) and fifth grade strategic reading level girls (79%). This data set indicated that the use of nonstandard terms to represent mathematics concepts and wording of the questions may be negatively impacting students' ability to solve mathematics problems. Details containing how many students in each group missed these types of problems are shown in Table 26.

Table 26

Ratio of Students Who Incorrectly Answered Questions Containing Nonstandard Math Terms and Difficult Wording

Grade Level	Intensive	Strategic	Benchmark
3	7/24 (29%) M	9/30 (30%) M	19/78 (25%) M
	20/30 (67%) F	23/66 (35%) F	27/78 (35%) F
4	8/28 (29%) M	8/35 (23%) M	16/77 (21%) M
	20/35 (57%) F	34/63 (54%) F	29/70 (41%) F
5	20/35(57%) M	11/28 (39%) M	14/56 (25%) M
	F*	11/14 (79%) F	24/70 (30%) F

Note. The first number indicates that number of students who missed the question; the second number is the total number of responses.

Multiple meanings within questions. When examining constructed response mathematics problems, it was determined that some questions had words, directions, or interpretations that could take on multiple meanings. No points were earned by students that, by their given answer, seemed to have interpreted the meaning of the question incorrectly. In some cases, the answer could have been correct based on answer translation.

The first example of an incorrect translation of a multiple meaning word was found on a third grade test. The question asked students to find the difference between a given number and a number they had corrected in the first portion of the problem. To earn the points for this question, students need to subtract the two numbers. Seven students (14%) gave answers that told how the numbers were different. For example, some said one number was odd and the other number was even. This was a correct statement, though it did not earn any points. Another example was telling how each place value position contained a different number and had a different value. Again, this was a correct description of the difference between the two numbers. A final example was stating that one number was larger than the other, a correct observation of difference but not a correct response. This specific error was made by at least one person in each gender group and reading level with the exception of intensive reading level girls. Among benchmark reading level boys, three students made the error. In this case, a student with a higher reading level has more experience with words and would know the multiple meanings of the word difference.

A second example of an incorrect interpretation was on a question requiring an understanding of measurement concepts. In the question, three students were working on a project together and each needed a specific amount of fabric. The question first told how much fabric each student needed and then asked how much fabric was needed in all for the project. The correct response required the student to use the amount of fabric for one project and multiply it by 3. A student could have easily deduced that the three students would need one piece of fabric for the project and not multiply it by 3. This error was made by a male student in the intensive reading level group. Students in this group may not have comprehended the fine detail of each student needed a piece of fabric. Another issue with this question was that it was also considered a question with an unfamiliar scenario. The possibility for multiple interpretations and the unfamiliar scenario combined could have easily been the cause of students answering incorrectly.

The next example of a question with multiple interpretations was found on a fourth grade assessment. This was the third part of a three-part question. The first two parts required students to use clues and place value knowledge to find two different numbers. The last part of the question asked students to “write a number sentence to compare the two numbers” using greater than, less than, or equal to. To earn a point, students needed to use each of the numbers they created in parts 1 and 2 in the number sentence and compare them. Of the 42 students who answered this question, 16 (38%) compared two new numbers. The key word in this question that told students to compare the numbers they had found in parts 1 and 2 of the question was the word "the." This one word made a difference in the number of points earned for 38% of the students. This error was made among all the groups except for strategic reading level boys. Four students from the intensive reading level and five female students from the strategic reading level compared two new numbers. This question also comes at the end of the test. It is the first part of a three-part question that makes up the last question of the test. At this point, students would have already read 376 words. Those students who do not read fluently may have been running out of time to complete the test when coming to this question. If this were the case, time to read the question and then reread it for further comprehension may not have been available. This indicated that students reading at levels below benchmark struggled with questions, possibly due to reading fluency.

The final example of a multiple meaning interpretation of a question was found on a 5th grade assessment. The question assessed students' understanding of types of angles and their measures. A picture of a car speedometer was shown with the speedometer needle pointing to 35 miles per hour. This formed an angle. Students were asked to tell if this *formed an acute angle and use measurements to support the answer*. The correct answer was that the speed did form an acute angle. However if instead of looking at the angle formed between 0 and 35 miles per hour, the student could have looked at the angle formed between 35 and 120 miles per hour which would have been an obtuse angle. For this question, 11 students of the 29 (38%) who took the test said the angle was obtuse. Four of the students missing the question read in the intensive or strategic range. This question also came at the end of the test. It was the first part of a three-part question that made up the last question of the test. At this point, students had already read 392 words. Those students who did not read fluently may have been running out of time to complete the test when coming to this question. If this were the case, time to read the question and then reread it for further comprehension may not have been available. The intent of the question was unclear and multiple interpretations are possible.

Summary

A qualitative analysis was conducted to determine how reading fluency affected mathematical problem solving and to establish error patterns. The data were analyzed by gender, reading level, and grade level. The overall analysis supports the theory that students with lower reading fluency level, perform lower on mathematics problem solving. Patterns were established showing how reading fluency levels related to mathematics problem solving. Patterns included the impact of mathematics vocabulary, mathematics problem context and wording, and amount of words per question. The common theme throughout the qualitative analysis was that students reading at the benchmark reading level most often outperformed students at the strategic and intensive reading levels. In conclusion, it was determined that when reading fluency is at benchmark level, mathematics problem solving improves.

CHAPTER 5

DISCUSSION

The foundation of education is the ability to read and comprehend text. Concepts of reading begin in the early stages of life when toddlers and preschool-age students hear rhymes and begin to make letter and sound connections. The first years of school are devoted to teaching students how to read. Reading is the skill upon which all other knowledge is built. It seems logical that if a student excels in reading he or she would excel in other academic areas. The opposite also seems logical: if a student struggles in reading, then he or she must struggle in other academic areas as well. The questions for this study asked how reading fluency affects mathematical problem solving.

This research used DIBELS ORF scores and ISTEP+ mathematical problem solving scores to determine if reading fluency had a relationship with mathematics problem solving. Through quantitative and qualitative analyses between the two, effects of reading on mathematics and error patterns were established.

Discussion of the Findings

Ten questions were asked about ORF and mathematics problem solving. In general, it was determined that reading fluency does have a relationship with mathematics problem solving.

Research Questions 1 and 2 asked if there was a significant relationship between students' oral reading fluency scores and mathematics constructed response scores. These questions were addressed through an analysis of the entire data set and for both gender groups. It was determined that a significant linear relationship did exist between DIBELS ORF scores and ISTEP+ mathematical problem solving scores.

A scatterplot illustrated the positive linear relationship. The graph depicted a set of point that as DIBELS ORF scores increased so did ISTEP+ mathematical problem solving scores. A regression equation was also determined for all three groups. Prediction of future ISTEP+ mathematic problem solving scores can be made from DIBELS ORF scores from these equations. The equations were statistically significant for the whole group, boys group, and girls group. This significance allowed me to reject the null hypothesis and state that predictability does exist between DIBELS ORF scores and ISTEP+ mathematical problem solving scores.

Research Questions 3 and 4 asked if there was a correlation between DIBELS ORF scores and ISTEP+ constructed response scores and specifically if it was stronger for one gender. The Pearson correlation was conducted for the whole group, boys, and girls groups. It was found the DIBELS ORF scores and ISTEP+ mathematical problem solving scores were significantly positively correlated for all three groups. The correlation was strongest for Female Group at $r^2 = .710$, moderate for the whole group at $r^2 = .53$ and low for the whole group at $r^2 = .344$. This information allowed me to reject the null hypothesis and state that there is a relationship between oral reading fluency and mathematical problem solving.

Research Questions 5 and 6 asked what common error patterns related to reading fluency can be detected on ISTEP+ mathematical constructed response and Acuity Diagnostic assessment. The error patterns were determined for the whole group data set and by gender. Several error patterns were determined. Through the qualitative analysis it was discovered that the oral reading fluency level, wording of the question, and the use of unfamiliar scenarios and names all effected mathematical problem solving skills. These error patterns had a negative effect on all three groups, but the students most often affected were those reading at the strategic and intensive levels. The negative effect was greatest for those reading at the intensive level. Overall, the intensive reading level girls seemed to have the most incorrect answers in mathematics due to the above mentioned error patterns. Though strategic reading level boys were impacted by the error patterns, the percentage of boys in this group answering incorrectly was often equivalent to the boys in the benchmark reading level group.

Research Questions 7 and 8 asked what errors in mathematical problem solving ability are related to mathematical vocabulary knowledge for the whole group data set and for gender. The examination of the test led to the finding that most of the questions contained mathematics vocabulary. Incorrect answers for questions with mathematics vocabulary were most often given by intensive reading level students, both male and female, although all reading level students had incorrect answers for those questions including mathematics vocabulary. Often the mathematics terminology used words that had other words that could be considered their opposite, e.g., odd and even or least and greatest. A separate analysis was completed for these types of words. Consistent with the findings for vocabulary in general, intensive reading level students of both genders most often answered these questions incorrectly.

Research Questions 9 and 10 asked if errors in mathematical problem solving ability are related to the amount of reading required in the problem and was analyzed for the whole group and by gender groups. Amounts of words in each question were determined and then categorized into low level, medium level, and high level of words. The intensive readers again had the highest number of incorrect answers. The benchmark girls had the lowest number of incorrect answers on all levels of words on both assessments in each grade level with the exception of the fifth grade high word level groups. This data showed that the lower reading fluency levels more often incorrectly answered questions of all three word levels. These data again supported the previously concluded qualitative data that the benchmark reading level students who had the highest fluency tended to outperform the intensive reading level students who have the lowest fluency on mathematics assessments.

Educational Implications

A significant moderately positive correlation for all students, and a significant high positive correlation for girls specifically, was found between reading fluency and mathematics problems solving. This supports earlier research conducted by Ackerman et al. (1996) and Casto et al. (1996) that found mathematics success or failure was related to reading disorders. Similar findings from Jordan et al. (2003) and Vilenius-Tuohimaa et al. (2008) are also consistent with the current study that reading ability influences mathematical ability. A study by Keller-Margulis et al. (2008) found reading fluency was a significant predictor of performance on standardized tests, which supports the significant correlation found between ORF scores and ISTEP+ mathematics scores.

When examining the qualitative date, it was determined that most often students in the benchmark reading level outperformed those students in the lower strategic and intensive levels. Rangappa (1993) also found that students divided into reading groups based on ability showed a significant difference in mathematical ability. Rangappa’s research is consistent with the current qualitative data. He found those in the higher reading group out-performed those in both the average and low reading groups significantly. With this in mind, educators can guide their instruction to stress an increase in reading fluency.

Fluency Instruction

A focus on fluency instruction should be at the forefront of reading instruction. Fluent reading is a foundation of comprehension and an important component of reading instruction Rasinski et al. (2005) and Wise et al. (2010) have also researched fluency and reading ability and have determined fluency does have an effect of overall reading competence. Beginning early in school, students will need opportunities to practice reading fluency. Using programs such as DIBELS, students can be tested three times per year and progress can be monitored throughout the year so teachers are aware of students' oral reading fluency levels (University of Oregon, n.d.b). Another tool commonly used to practice fluency is *Reader's Theater*. These simple plays from Rasinski and Padak (2004) provide educators with text to use with students for repeated reading. Regardless of the method, reading fluency will need to be a focus for students due to its impact on mathematics problem solving.

When students do not read fluently, they do not comprehend as well as those students who do read fluently (Beringer et al., 2010; Wise et al., 2010). If students are not able to comprehend text, they will have a difficult time with mathematical problem solving due to the level of comprehension needed to understand the problem as was found in this study. Students may need to sort through unfamiliar names and scenarios and difficult wording to determine the actual computation needed to solve the problem. Students in this study reading at the benchmark level showed the most success with this skill. Benchmark readers tend to have higher levels of comprehension. Since reading fluency and comprehension are related, increasing fluency will increase comprehension. An increase in both these skills should have a positive effect on mathematical problem solving. For this reason, fluency instruction is needed.

When examining the number of words in mathematics constructed response problems, some problems had a large number of words to read. Students in this study reading at the intensive level were more likely to miss questions with a large number of words to read than those students reading at the benchmark level. Two things to consider are that the more words read per minute equate to a higher fluency level and that standardized tests are timed. For those students reading at the intensive level, they may not have enough time to read and reread mathematical problems for comprehension. By increasing a student's fluency, there will be an increase in the number of words read per minute. This increase will lead to students being able to read through a mathematical constructed response problem more quickly and in turn have a greater level of comprehension and more time to solve the problem.

A major concern for students who do not read fluently is the amount of energy they expend on decoding words. When a student does not read fluently the majority of his or her cognitive capacity goes to decoding (Baker et al., 2008; Rasinski et al., 2005; Wise et al., 2010). When students are working on mathematical problem solving, they are not able to concentrate on the problem if all of their cognitive energy is being used to decode and recall words. For those readers in the intensive range, their lack of fluency truly inhibits their ability to solve mathematics constructed response problems. Those students who are not expending cognitive energy on decoding are performing better since they can focus on the mathematics problem instead of the text. Students at the benchmark reading level comprehend at a higher rate. As shown through this study's analysis, these benchmark reading level students also solve problem in mathematics at a higher rate.

Focusing on reading fluency during reading instruction is a needed component of a student's education. Educators might also consider fluency instruction during mathematics.

Practicing fluency using mathematics constructed response problems will help students specifically increase fluency within this reading genre. Considering mathematics reading as a genre to be studied and practiced will provide students with more exposure to mathematics constructed response items. Using these types of problems to practice fluency would benefit all students, but the contact will be especially beneficial to intensive level readers as demonstrated through this study.

Vocabulary Instruction

When examining both the ISTEP+ and Acuity Diagnostic mathematics assessments, it was determined that mathematics vocabulary was part of the majority of questions. The percentage of mathematics vocabulary words per test range from 57% to 93%. This statistic alone tells educators that mathematics vocabulary should be a focus of instruction. Students need to be able to recognize and comprehend mathematics vocabulary words to be successful problem solvers.

Beck et al. (2002) developed a structured technique for teaching vocabulary words during reading. The method Beck et al. (2002) used to teach vocabulary has been proven to work with children of all ages. Their methods help children know words and be able to interact with them. The words they are learning are seen and used in both reading and writing so their approach is perfect for language arts. Mathematics vocabulary words are Tier 3 words, words specific to content, and are taught when needed. Students and teachers work together to choose pictures that go with the word. The pictures and the words are displayed together and the picture acts as a clue for word meaning. Teachers and students also work together to devise a definition and sentence that are written in student language, which are correct but give personal meaning. The method they use gives students ownership of the words due to the fact that they are developing the definition, sentences, and pictures associated with the words. Students learning words from this method have a knowledge of the words that is greater than that of students who just copy definitions (Beck et al., 2002). This vocabulary teaching technique would be very beneficial during mathematics. Many of the errors made by students were on questions with specific mathematics vocabulary and specifically when the word had an opposite meaning such as odd and even. Increased word knowledge would help students more often correctly answer questions in which a mathematics vocabulary word appeared and its definition was required in order to reach a correct answer. Increasing student word knowledge of mathematics vocabulary would benefit all students but especially those at the intensive reading level.

Another implication for building mathematics vocabulary ties with fluency. It seems that mathematics vocabulary words are often just seen and used in the confines of math instruction. Often the words are just said by the teacher and the student. This requires an oral comprehension of the word, but tests require the student to read and comprehend the word. Mathematics vocabulary words should be displayed in printed form for students to see and read frequently. Displaying the words in this way would give the students opportunities to see and read the mathematical vocabulary words more frequently and in turn increase their fluency with these words.

Specific Mathematics Problem Solving Instruction

The qualitative portion of the analysis established error patterns commonly made by students in mathematical problem solving. Some of the error patterns included the use of unfamiliar names and scenarios. It was determined that those students reading below the benchmark level struggled with these types of questions more often than those students reading at the benchmark level. An analysis was completed to determine how the number of words impacted student success. Students reading at the intensive and strategic reading levels were more likely than benchmark reading level students to miss questions with high levels of words. When examining overall scores on the ISTEP+ assessment, it was determined that those students passing language arts and also reading at the benchmark level were most likely to pass the mathematics portion. Those students succeeding in language arts were also succeeding in mathematics.

Since mathematical problem solving comprises a large part of assessments, specific instruction on how to solve these types of problems is needed. Often students repeatedly work computation problems in a technique known as “skill drill.” This continual practice is done in order to help students master the skill. If practicing a skill helps students to become better at the skill, then practicing mathematics problem solving is necessary.

Simply exposing students to mathematics constructed response problems will help them become more fluent at reading them and more familiar with their set-up (Fuchs et al., 2009). When sharing mathematics constructed response exemplars, samples, discussion related to unfamiliar names, scenarios, and wording can be discussed. Suggesting to students that when they see a name they do not recognize to replace with a name they know may help them better comprehend the problem. Intensive reading level students had the highest percentage of students missing questions with uncommon names. Using a replacement name would give them a strategy that would allow them to move beyond the unknown name and continue with the problem.

For some tests, almost 20% of the questions had a context or scenarios that would be unfamiliar to students. Vilenius-Tuohimaa et al. (2008) stated that, in order to solve a mathematics problem, the reader must first understand the meanings of the sentences and then apply prior knowledge to the specific problem. For many students, a lack of prior knowledge may inhibit their ability to solve the problem. Smekens Education Solutions (n.d.) used a strategy for unfamiliar scenarios found on standardized writing prompts. This technique teaches children that if they do not have a personal experience with the context to think about other people, books, or media that may have had the experience. Finally, if that fails, just make up something. This technique could be adapted to fit mathematics constructed response questions. When students read the problem, they may get hung up on the “story” part of the problem. For some students with few experiences, they are unfamiliar with scenarios such as cutting fabric for a project. This unfamiliarity may inhibit comprehension, but if the students just think of someone they know who has had the experience or maybe they have seen it on television, then they can make a better picture in their minds for the context of the problem. Being able to picture what is happening in a mathematics constructed response problem may aid in comprehending the problem and then answering it correctly. This strategy may be very helpful to those intensive level readers, especially girls since they had an incorrect answer rate of almost 90% on mathematics problem solving with unfamiliar scenarios.

A final strategy to help students improve their mathematics problem solving also comes from language arts instruction. When reading, students use graphic organizers to organize the text in specific ways. They may organize the features of the story, cause and effect found in the story, or clues leading to the author’s purpose (Fountas & Pinnell, 1996). Using a graphic organizer to organize the components of a mathematics constructed response question may benefit students of all reading levels, but especially those in the intensive level. When reading a problem, students should think who the question is about, what information they have (numbers or data), how they are going to manipulate the question (computation), and what the question is asking. Much of the challenge in mathematical word problems is organizing the information (Manzo, 1975). Organizing these parts in a graphic organizer can help students to see the important components to the problem. Since problems have so many different patterns that can cause error for students, a strategy for organizing the problem may be advantageous.

Students need to know and understand the connection between reading and mathematics. Improving reading fluency will help students, especially those in the intensive reading level, to also improve mathematical problem solving. Teaching specific mathematics vocabulary and giving students opportunities to not only hear the word but also see it in print will increase their vocabulary knowledge. This is important since so many of the questions they will encounter contain specific vocabulary. Because a relationship does exist between reading fluency and mathematical problem solving, showing students strategies that relate to both areas will be beneficial.

Test Developers

There are several companies developing tests to assess student mathematics problem solving ability. Knowledge of errors students make on assessments of mathematics due to poor fluency could be beneficial to the developers. Their awareness of the error patterns would enable them to eliminate some of the extraneous reasons poor readers are not successful mathematics problem solvers. When writing questions for mathematics assessments, the developers could be more aware of the number of words used, the types of scenarios given, along with terminology and wording. Although tests of mathematics need to test mathematical knowledge, eliminating the error patterns found in this study may help the test to assess mathematics instead of reading fluency.

Parental Notification

Improving student success happens when educators and parents or guardians work together. Parents need to be aware of the impact reading fluency or lack of reading fluency has upon their children's performance. This understanding may encourage parents to read more often with their children outside of school. Extra time spent reading will help increase a student's reading fluency level. Schools could hold mathematics and reading nights where parents could come to learn more about the impact reading fluency has upon their children's success in the entire academic arena. Attendance at such events is often increased by serving food and having entertainment provided by the students. At these events, tips and techniques on ways parents can help their student increase reading fluency could be shared. Parents should also be notified of their children's fluency level throughout the school year. Many programs used by educators, such as DIBELS, contain a parent report component (University of Oregon. n.d.a). With reading fluency playing such a large role in students' mathematic problem solving ability, parents would best serve their children by spending time reading with them in addition to working on mathematics problems.

Limitations

Limitations were found in this study. The population sample for this study all came from the same school, and the extent to which these students represented all third, fourth, and fifth graders limits the study. Students who did not have data from all three assessments were eliminated from the study. Students in high poverty areas tend to move between schools often and do not come from a stable school setting. Constant movement to and from schools must have some effect on learning. Data were not available for students who had not been at the specific school for all three testing windows, though these students possibly would have taken the assessments depending on the school they were enrolled in at the time of the assessment window. Being able to access their complete data set and then including them in the study would have made this study more generalizable to the population.

Those students identified as having specific learning disabilities, mild disabilities, or communication disorders were eliminated to avoid a skew of the data. These students had the mathematics portions of both the ISTEP+ and Acuity Diagnostic assessments read to them. By not including special education students in the data set, the results of the study are not generalizable to entire elementary school populations.

The data sources were from three specific testing windows during the 2009-2010 school year. The overall percentage of students passing the assessments during that time period may have been lower or higher than subsequent years. Using data over several years would have strengthened the study. Data could have also been tracked specific to each student and, as DIBELS scores increased or decreased for that specific student, an examination of how his or her ISTEP+ and Acuity Diagnostic mathematics scores changed could have been determined.

Further Research

The Relationship Between Oral Reading Fluency and Mathematical Problem Solving was an exploratory study. It was completed to determine if a relationship did exist between the two variables, and the quantitative and qualitative data proved there was a relationship. The review of the related literature confirmed that research related to the topic was limited. Because of the relationship between oral reading fluency and mathematical problem solving and due to the limited current research, further investigations should be completed.

For this study, the population was limited to one school in a high poverty area. Data from multiple schools with differing demographics could be analyzed to determine if significant correlations and predictability continue to exist. The data could be further analyzed by grade level, ethnicity, and socio-economic status groups.

This research looked at the relationship between oral reading fluency and mathematics problem solving. It used DIBELS ORF scores as a measure and a predictor of ISTEP+ mathematics problem solving. For further research, a different predictor variable could be used such as knowledge of basic math facts, understanding of mathematics vocabulary, or standardized reading comprehension scores. In addition, the variable DIBELS ORF could remain the same and be used to predict standardized test scores for language arts or writing prompts. Due to the fact that DIBELS data often go back as far as the kindergarten year for some students, tests other than ORF, such as Phonemic Awareness and Segmentation, Word Use Fluency, or Nonsense Word Fluency could also be examined to determine a relationship with mathematics problem solving (University of Oregon, n.d.b). There is also a mathematics component to DIBELS testing and data from these assessments could also be used as a predictor variable. In summary, changing the assessments and/or scores, but continuing to find significant relationships between reading and mathematics used, could reveal new insight to further help educators.

For this study, special education students were eliminated from the study. This was done because many of these students had the mathematics portion of the ISTEP+ assessment read to them. Further research could include special education students. A test could be given to these students that they had to read for themselves. This study could further be explored by using a test at the student’s current grade level and a test at the student’s reading level. Since many students with specific learning disabilities achieve at grade level in mathematics but not reading, it would be interesting to know how much their reading fluency and comprehension levels are impacting their mathematics ability when working independently.

The qualitative portion of this study was observation data and left to my discretion. Much data, however, were gathered through these observations. Further research could expand upon this information and statistically analyze it for significance. The information related to student performance, whether at or below target, on language arts could be easily exchanged for DIBELS ORF as the predictor variable.

Another aspect of the qualitative analysis was to look at the overall point total for the constructed response questions on ISTEP+ mathematics assessment. Point values were then termed passing or not passing. Tests for those students who, according to my analysis, did not pass were examined to determine if the student passed math overall. Percentages for students who did not pass the mathematics constructed response portion yet still passed ISTEP+ Mathematics overall were calculated. This too is an area for future research. If it were known how much of the score was made up from each portion of the test, a statistical analysis could then be completed to determine the relationship between oral reading fluency and mathematics constructed response as well as constructed response questions' impact on overall mathematics passing rates.

Questions were categorized by level of number of words. The levels used were low, medium, and high. These groups were devised by using the range of words in all the questions and then dividing that range into even groups for low, medium, and high. This analysis could be done more precisely and accurately. Then a statistical analysis of the effect of words per question on mathematics problem solving could be calculated.

Much information was gathered by looking at the assessment questions and by the answers students gave. For this study, percentages of students in each reading level who answered questions incorrectly and the number of instances an error pattern occurred were calculated. Further research could take much of this information and analyze it statistically in order to determine if the error patterns were a significant cause of why students missed the questions. These data too could be further broken into more groups for ethnicity, socio-economic status, and special education categories.

Summary

In conclusion, research was completed to determine if a relationship existed between a student's oral reading fluency and mathematical problem solving. Though it seems obvious that reading ability would affect mathematical problem solving ability, research to support this is limited. Even more specifically, how reading fluency affects mathematical problem solving ability was even more limited. For this study the quantitative data showed a significant positive correlation and predictability for DIBELS ORF scores and ISTEP+ mathematical problem solving scores. This significance was found for the whole group, boys, and girls. The qualitative analysis found error patterns related to reading fluency, which included the overall number of words per question, mathematics vocabulary, and question content. This study supports the hypothesis that a relationship exists between reading fluency and mathematical problem solving.

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APPENDIX A: APPROVAL TO COMPLETE STUDY

Study Approval
Michele Walker [mwalker@doe.in.gov]
Sent: Monday, June 27, 2011 5:58 PM
To: Amy Norris
Cc: Christi Fenton [caf@vigoschools.org]

Amy:
This email serves as IDOE approval for your quantitative and qualitative study, which will include data from DIBELS, ISTEP+, and Acuity. Please be sure to forward a copy of your approved Human Subjects paperwork to my office.
I wish you the best as you embark on this endeavor!

Kind regards,
Michele
Dr. Michele Walker, Director
Office of Student Assessment
Indiana Department of Education
Office Location: 151 W. Ohio
Indianapolis, IN 46204
Telephone: 317.232.9050
Toll Free: 888.544.7837
Fax: 317.233.2196
mwalker@doe.in.gov
www.doe.in.gov

FILE: LC-E & IFA-E

VIGO COUNTY SCHOOL CORPORATION
REQUEST FOR PERMISSION TO DO RESEARCH

TO: SUPERINTENDENT
From: Amy Walker   Position ISU Graduate Student

CONTACT ADDRESS 8398 S. Singhurst St. Terre Haute, IN CONTACT TELEPHONE 240-8574

SUBJECT: To determine if math problem solving scores can be predicted from DIBELS ORF scores
(Nature of Request to do Research)

1. Grade Levels Involved: 3rd, 4th, and 5th
2. Number of Pupils: Approximately 130
3. Name of Schools: Deming Elementary
4. Amount of Pupil Time: Daily Basis none Cumulative Basis no
5. Starting Date: Pending approval from ISU – June 2011
6. Completion Date: December 2011
7. Responsibilities of:
   a. Teacher none
   b. Principal Will be given master sheet of students' scores and code numbers to keep
   c. Investigator statistically analyze data
   d. Pupils none
8. Brief Summary of Project Requests: This project contains both a quantitative and qualitative component. ORF scores will be use to try to predict math problem solving scores on ISTEP. An error analysis of pattern on math problem solving items will be determined.
9. Attach one copy of the complete research proposal and mail to:

Ms. Christi Fenton
Vigo County School Corporation
686 Wabash Ave.
Terre Haute, IN 47807

Recommendation of Review Committee (Members)	Approved	Denied	Additional Information Needed
Christi Fenton	✓		
[illegible]	✓		pending approval from ass compan

Date April 13, 2011

Permission to Use Data – DIBELS

Re: permission to use data
DIBELS Data System Support [support@prod1.dibels.uoregon.edu]

To: Amy Norris
Hi Amy:
Since the data doesn't belong to us, the permission must come from the school district. We merely house the data on behalf of a customer. The customer (school district) owns the data. Therefore, we aren't able to give permission to use a customer's data to anyone. We have strict confidentiality policies preventing us from releasing data to anyone.
It's curious that the district would tell you that we need to give you permission to release their data. We are categorically unable to do so.
Best of luck on your dissertation :-)
Tessa Pierce
Technical Support Specialist
DIBELS Data System
University of Oregon
Toll-free (888) 497-4290
Fax (541) 346-4349
Check out our "Frequently Asked Questions" at https://dibels.uoregon.edu/faq.php. This is a good place to start for immediate help with many issues.

On Wed, 30 Mar 2011 15:38:56 -0700, Amy Norris <anorris@indstate.edu> wrote:

> To Whom It May Concern:
> I am a graduate student at Indiana State University. I am currently preparing my doctoral dissertation proposal. I would like to use DIBELS ORF data from 130 students in the Vigo County School Corporation/Terre Haute, IN. I am also a teacher in the Vigo County School Corporation so I use DIBELS and have access to student scores via mClass. My research will be to determine if ORF scores for students grades 3-5 can predict problem solving scores found on a standardized measure. All identifying characteristics will be removed from the data and all student data will be kept confidential. This process of removing identifying characteristics and coding the data for use will be done by a staff member other than myself who works at the school.
>
> I have made a request to the Director of Elementary Education and Deputy Superintendent of my school corporation to use this data. They will not grant this permission unless I have received permission from you to use this data. After speaking with someone at your provided phone number, it is my understanding that the data belongs to the corporation and I do not need permission.
>
> If you are able to assist in this matter, please advise me as to how I can either obtain written permission to use the data or a written statement that I do not need permission from you to use the data.
>
> I greatly appreciate your assistance in this matter,
>
> Sincerely,
> Amy (Norris) Walker
> 8398 S. Singhurst St.
> Terre Haute, In 47802
> (812) 240-8575

Connected to Microsoft Exchange

APPENDIX B: MATHEMATICS TERMINOLOGY

Acute
algebraic expression
Angle
Area
Base
Coin
Compare
Diagram
Diameter
Difference
Digit
Displays
Equal
Equation
Equivalent
evaluate
even
expression
feet
figure
fraction
gave away
greater
had left
has left
height
hours
how much more
hundreds place
hundredth
in all
in all
inches
increased
left over
length
less
line segment
long
measurement
nearest
number pattern
number sentence
numbers
obtuse
odd
ones
ones place
perimeter
portions
product
radius
rectangle
rectangular
remaining
remaining
removing
represent
right
rotational symmetry
rounded
shaded parts
solve
square centimeters
square feet
square units
subtracted
Sum
symbols
symmetry
ten thousands place
Tens
tens place
thousands place
total
triangle
value
whole number
wide
width