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Integrating Reading into Mathematics Instruction

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By
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Abstract

Reading is not often thought of as a topic that affects mathematics, but it is a reality for low-level reader students. The purpose of this qualitative study was to explore how teachers describe the relationship between mathematics and literacy skills, and to explore specific methods mathematics teachers used to accommodate low-level readers in their mathematics instruction. Participants were six teachers from a rural elementary school. Data was collected through recorded interviews and supplemental email questions that were coded. The data gathered showed that teachers use literacy in mathematics classrooms through word problems and mathematics stories. The most common accommodation was pairing low-level reading students together with a higher-level reading student.

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Introduction

Concepts learned during one's educational career tend to cross into other domains of learning. One concept introduced at the Pre-K level, and continually grows upon even after schooling ends, is literacy. Literacy includes reading and writing, reading comprehension, and vocabulary development. The mastery of such a critical skill is important to supporting a better quality of life. Some aspects of life in which mastery would be more apparent than others would be working, shopping, and communication. However, an unusual connection with literacy has surfaced in an area that is not normally thought of but very important to the world today: mathematics. There have been several studies probing into the relationship between mathematics and reading.

Kyttälä and Björn (2014) found that when solving math problems, especially those that are presented in written form, literacy skills are crucial. Kyttälä and Björn studied adolescents, but in a study conducted by different researchers that explored sets of twins between the ages of eleven and twelve, the same results found to be true with this age group (Harlaar, Kovas, Dale, Petrill, & Plomin, 2012).

There were several different countries that have taken an interest into understanding the relationship between mathematics and reading. Content area reading has gained attention among researchers after the publication of National Reading Panel in 2000. This study will add to the work conducted in the United States on how the teachers view the relationship between mathematics and reading and what are their techniques for infusing reading in the mathematics classroom for specifically lower-level readers.

To understand what teachers observe between literacy and mathematics skills in the classroom, I have conducted a qualitative study focusing on teachers and their experiences with infusing reading in their mathematics classroom.

Purpose Statement

The purpose of this research was to explore how teachers describe the relationship between mathematics and literacy skills and how they use literacy in their mathematics classrooms.. Through a qualitative design, data has been gathered to explore specific methods mathematics teachers are using to accommodate low-level readers in their mathematics instruction. The following questions guided the study:

1. What is the role of reading in mathematics instruction according to teachers?
2. How do teachers accommodate low-level readers in their mathematics classroom?

Review of Literature

The literature review references two different literary contexts: teaching of mathematics, and the relationship between mathematics and reading. Articles supporting the research were found from reputable statistical reports and scholarly, peer-reviewed journals. The articles are divided into the two different groups based on their findings and addressed including main findings, goals, and brief overview.

Teaching Mathematics

Teaching is a profession that develops with the years that go by and each student that steps into the room. Children all learn differently and teachers have to adapt to effectively teach students content. Discussed here is research about general teaching as well as teaching mathematics.

A study regarding teacher quality and instructional practices compared student achievement across two countries. This quantitative study (Dodeen, Abdelfattah, Shumrani, & Hilal, 2012) compared teachers from Saudi and Taiwanese with regard to teacher preparation, professional development, and their respective eighth grade students' achievement scores. The researchers (Dodeen et al., 2012) selected two countries whose student scores ranked at the extremes on the achievement scale to assess quality and practices differences based on questionnaire results. Results indicated that teachers need to be prepared to teach all mathematics topics in eighth grade for optimal student achievement and that positive support from parents, as well as improved professional development, are helpful in improving student outcomes. The results also indicated that from these two countries with diverse student performance history reinforce the positive impact of teacher quality on student achievement.

Another qualitative case study (Obara & Sloan, 2009) investigated the experiences of three fifth grade teachers and their math coach as they worked with new instructional materials during the implementation of a new state-mandated standards-based curriculum. In a Georgia elementary school, where 80% of the students were low SES and only 21% were white, it was revealed the importance of a mathematics coach to assist teachers during the transition into reform curriculum. This study drew attention to the prevalence of low SES students in rural schools. Also, researchers highlighted limited teacher access to necessary supportive reform resources and training in the rural setting. Data drawn from audio-recorded interviews, video-recorded classroom observations, field notes, student work, and teachers' materials led to conclusions regarding teacher

perception of the transition from traditional to reform curriculum. The study indicated that the hiring of math coaches had transpired due to inadequate teacher resources, few workshops, insufficient training, and no state-approved textbooks to support the new curriculum. Although teachers indicated they had revamped their instructional mode, data collected by the researcher indicated relatively little change in instruction from the traditional practices of before. The study concluded that teachers need time and supportive resources to properly transition from traditional to reform curriculum. This conclusion heightens the awareness of the proposed study to focus on whether teacher practices are limited by sufficient time and supportive resources.

Cummins and Stallmeyer (2011) studied a group of 21 third grade students during assessment-driven instruction and if the students understood the text using different methods. The teacher had the students read a text independently and then write a response. They then read a different text aloud to the class and had the students complete another written response. Cummins and Stallmeyer found that students tended to write about specifics and not the main idea after reading independently, but some were able to correctly identify and explain the main idea after the read aloud and prompting. Instruction was then modified over several sessions to help the students synthesize the text. By having students interact with one another thus different levels of comprehenders and directly instructing the students how to synthesize the text lead to most of the students' responses being able to identify the main idea.

Relationship between Mathematics and Reading

Reading is a skill that follows the children further than English Language Arts class and extends into other subject areas. One area strongly correlated to reading that is not as expected as others is mathematics. Several studies have examined the relationship between reading, mathematics and student outcomes (Kyttälä & Björn, 2013). We have briefly discussed how strongly mathematics and reading are tied together but behavior is just as strongly tied to reading and mathematics according to Lin, Morgan, Hillemeier, Cook, and Maczuga (2013).

Georges (1929) conducted a study to discover the reasoning behind students' difficulties in mathematics. Georges hypothesized that by analyzing the reading difficulties one would also uncover the struggles in mathematics. Georges took forty first-year junior class students in the University High School of the University of Chicago. Teachers of these students observed them during class noting which students were having issues with specific problems. These students were then called into an interview with J. M. McCallister, who was also assisting with this research. McCallister presented the student with a math problem from Breslich's *Junior Mathematics* that the students were then asked to solve. McCallister made note of the processes and reactions, then gave each report to the student's instructor. A total of 188 reports were made.

The results of Georges study indicated that there are six types of reading difficulties associated with mathematics. The first difficulty identified was not understanding and interpreting a statement, which involved vocabulary and symbolism that has a different meaning specifically for math. This accounted for about 37.2% of all

of the difficulties. The second difficulty was the inability to perform mathematical processes and relationships, which accounted for about 21.1% of the difficulties. The students with this difficulty were unable to perform the problem presented to them because they did not understand the concept. Lack of intensity of reading comprises the third reading difficulty. About 12.8% of the difficulties were due to not being able to read the material and not being able to grasp the full meaning of the problem. The fourth difficulty comprised of 10.6% of the student unable to analyze the problem. They cannot differentiate between needed and not needed material as well as make a visual representation from the text. The fifth difficulty is the lack of precision while reading. About 10.6% of the reading difficulties are attributed to this specific classification that Georges (1929) considers not a reading difficulty but rather a careless habit of students. The sixth and last difficulty arises from the way that the problem is worded. About 7.8% of the students did not realize there was more than one solution, did not understand an abbreviation, did not understand the meaning, or the problem did not contain the data they needed to solve.

Another study produced by Boonen, Schoot, Wesel, de Vries, and Jolles (2013) was conducted in order to,

> (1) investigate whether the component skills and basic abilities in the two processing domains explain unique variance in students' word problem solving skills. (2) examine the direct and indirect (via the component skills) effects of the basic abilities on word problem solving. (p. 273).

A group comprised of 128 Dutch sixth grade students from eight different elementary schools that participated in this study. The students were chosen by their CITO Mathematics test proficiency score while the elementary schools were chosen at random. The students were then divided into groups categorized by their performance on the test. Using the Mathematical Processing Instrument, three trained independent research-assistants administered the test in two sessions of 30 and 45 minutes. After each mathematics problem the students performed, a short interview was performed about the subject's nature of the representation that they used in order to come to a solution.

Within the study, Boonen, et al., (2013) found that the variation of student responses to word problems was due to two different skills that include production of visual- schematic representations and relational processing. Twenty-one percent of the relation between spatial ability and word problem solving could be explained by the production of visual-schematic representation. With that being said, 34% of the relation between word problem solving and reading comprehension could be explained by relational processing. This means that word problem solving is directly and indirectly related to both spatial ability and reading comprehension. As stated by Boonen et al., "these results contribute to the development of instruction methods that help students using these components while solving word problems" (2013).

Vukovic and Siegel (2010) studied several different factors of students that contribute to mathematic difficulties. This study was a four-year study within five elementary schools of the same, diverse district of Western Canada. The district consisted of working-class neighborhoods that had a high mobility rate. This is significant because

the study was over a period of four years following the same students. Vukovic and Siegel (2010) started with first graders that were proficient in English and were without severe cognitive developments. In the beginning, there were 164 participants but only 85 remained in the study. Because of the nature of the study, Vukovic and Siegel decided to include 99 of the students that participated between three and four years of the study. The participants were then categorized in one in three groups: Mathematics difficulty (MD), persistent mathematics difficulty (MD-p), and transient mathematics difficulty (MD-t). The students were then tested annually in the winter with a trained research assistant.

Due to the nature of the study, there were several factors that played into the results of the study. The results of Vukovi and Siegel's (2010) study shows that the MD-p group tends to be categorized by their depressed reading skills. A generalized finding indicated that all groups had a deficit on measures of mathematics and reading achievement.

Lin, Morgan, Hillmeier, Cook, and Maczuga (2013) conducted a study in order to answer: "Do mathematics difficulties increase children's' risk of reading or behavioral difficulties?" While taking into consideration all the constricting or confounding variables, the researchers followed a group of 9,324 children specifically between the third to fifth grades. Lin et al. (2013) used the data collected by the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999, which surveyed the students through the eighth grade. The students, schools, and parents were surveyed at several different time frames throughout the nine-year study.

The results indicate those with mathematics difficulties while in the third grade had a 5.14 times higher chance to tend to also have reading difficulties in the fifth grade than those students that did not have reading difficulties. While looking at his study, one must also acknowledge the results of the study show a strong correlation between reading and mathematics difficulties with behavior difficulties. The study showed that poor readers are more likely to have behavior difficulties in later grades. With this being said, the study also found that behavior difficulties in question did not produce poor readers unless one of the difficulties that the student had a prior history of was poor task management.

Another study investigated whether mathematics is differentially related to word coding and reading comprehension (Harlaar, Kovas, Dale, Petrill & Plomin, 2012). Harlaar et. al (2012) conducted a study that used 5,162 sets of pairs in England and Wales to complete the study. The researchers used the pairs in order to look at the phenotypic and etiological level of correlation between reading comprehension, word decoding, and mathematics. All of the participants had already participated in a similar study, Twins Early Development Study (TEDS). The researchers looked at the results from the reading and mathematics ability testing when the participants were between the ages of 11 and 12 years of age. The pairs that were excluded were those that had a cognitive delay or a medical syndrome. Researchers also excluded those that did not speak English as their first language. The twin pairs then went through another series of testing that assessed cognitive, reading, and mathematics ability as well as further testing for mathematics, word decoding, and reading comprehension.

The results of this study did contradict previous studies that had been published. Normally the terms word decoding and reading comprehension have been used interchangeably, but results of this study show that the terms should not be used interchangeably. The researchers also found that mathematics is more closely linked to reading comprehension than word decoding. For the purpose of my research, this is important because it shows a clear connection between reading and mathematics.

Kyttälä and Björn (2013) conducted a study in order to examine the relationship between eighth-grade adolescents' literacy skills and mathematics word problem solving skills. The researchers studied 99 eighth-grade students between the age of 13 and 14. All of the participants attended school in Helsinki, Finland and spoke Finnish as their first language. The study was blind to ethnic and cultural background. The participants participated in a series of tests that assessed their abilities in mathematics and literacy skills while also studying mathematic anxiety and visuo-spatial abilities. During the literacy skills, the participants were tested so that the researcher separated technical reading skills from reading comprehension.

Kyttälä and Björn (2013) found that, "both technical reading and reading comprehension were strongly associated with mathematics word problem skills" (p. 62). The researchers also found that calculation ability was interrelated with technical reading skills. This research adds to the literature showing there exist a strong link between literacy skills and mathematics word problem solving skills. Even after anxiety was controlled for, the research showed a stronger relationship among boys than girls.

Throughout several separate studies, similar results were prevalent in terms of the connection between reading and mathematics. Albeit several approaches to conducting these studies and several different age levels similarities exist that provide some conclusive evidence on the link between mathematics and reading. The result is that reading in some form is strongly related to mathematics, specifically mathematics word problem solving skills. Students need to have strong reading abilities in order to have strong mathematics abilities. This study seeks to examine the role of reading in mathematics according to teachers and how the teachers are accommodating for lower-level readers.

Methodology

The current study aimed to explore how teachers describe the relationship between mathematics and literacy skills as well as to understand accommodations that teachers made for low-level readers in mathematics instruction. The research design was a basic qualitative design using thematic analysis to determine similar themes among teachers' perspectives.

The research questions that guided this study are: What is the role of reading in mathematics instruction according to teachers? How do teachers accommodate low-level readers in their mathematics classroom?

Participants and Site

Interviews have been conducted with six teachers from Bulloch County School System Elementary schools. The participants have been selected from the researcher's field practicum placement and recommendations from current teachers. The interviews

were conducted face-to-face in the participants' classroom or available space. The interviewee set the time based on their convenience.

Data Collection

Data was collected during individual interviews. Each interview was conducted for approximately thirty minutes at a time that was convenient for the participant. The researcher obtained permission from the participant to digital record the interview for later transcription and data analysis. Further data was collected through e-mail messages. After initial analysis of the interview data, participants were sent more questions via e-mail to collect more data.

Findings

The interviews were transcribed verbatim. The transcriptions were then coded for similarities by reading through and underlining important information. Supplemental questions were sent via email to gain answers to additional questions. From those underlined portions in the interviews and emails, a frequency count was taken from teachers' responses regarding how reading is integrated into mathematics instruction as well as how low-level students are accommodated in mathematics instruction.

Table 1 below shows the frequency counts collected from teachers' responses to interview questions. The findings show that the most frequent ways that literacy was used in mathematics was reading mathematics stories and word problems and problem solving and creating problems. The frequency count for these was three teachers each. The most frequent accommodation for low-level readers was pairing the student with another

higher level student or partner work. Five out of six teachers talked about this accommodation.

A common pattern among teachers' responses in regards to accommodations for low-level students in mathematics classrooms is that there is a lack of agreement among strategies. Teachers tended to have a different strategy than other teachers that were interviewed based on what they have tried with their individual student.

Table 1

Frequency counts of teachers' responses

Literacy in Mathematics	**Accommodating Low-level Readers**
Reading mathematics stories and word problems (3)	Pairing student with another higher level student/ Partner work (5)
Problem solving and creating problems (3)	Teacher reading material to the student (3)
Explaining or defending students' answers (3)	One-on-One time with the teacher (1)
Building mathematics vocabulary (2)	Group work (1)
Reading and creating graphic organizers (2)	Drawing a picture instead of using written answers (1)
Reading directions (2)	Look for understanding instead of counting off for misspelling (1)
Written and oral presentations (1)	Highlighting key vocabulary in word problems with a bright color (1)
English Language Arts Leveled readers integrated into Mathematics (1)	Accepting shorter explanations for answers given (1)
	Giving specific cues for problem solving questions (1)

Reading mathematics stories and word problems

Three teachers talked about reading mathematics stories and word problems being one way that literacy is used in their classroom. These teachers were talking about any word problems that involved a reading component. A word problem can have not only mathematics terminology, but also everyday words that students could see anywhere. One teacher said that she has students read "math stories to introduce topic." The terminology that students might see would not only be everyday English words, but also words that are unfamiliar.

Another teacher said that "students must be able to read and understand word problems in math." She went on to talk about how a student was not able to read a word problem, so the student did not come to the correct answer. Once the teacher reread the problem to the student, the student understood their mistake and corrected it. Students misreading a mathematics story or word problem can lead to misunderstanding and incorrect answers.

Problem solving and creating problems

Three teachers talked about problem solving and creating problems being one way that literacy is used in their classroom. As one teacher describes, involves "reading and rereading for clear understanding, asking questions about the reading before, during, and after." It also involves student generated problems as an assignment that is used to check for understanding.

Explaining or defending students' answers

Three teachers talked about explaining or defending students' answers being one

way that literacy is used in their classroom. This is having students solve mathematics problems, then write how they came to their answer or write why all of the other answer choices are wrong and theirs' is correct.

All of the teachers that talked about this being a way that literacy is used in their classroom said that this is something that they do in a written format. The teachers have students defend their solution process by writing out the steps to their conclusion. One teacher also said that she has students pair up and discuss what they have written orally.

Pairing student with another higher level student/ Partner work

Five teachers talked about pairing students with either a higher level student or with a familiar partner as being one accommodation for low-level students in their mathematics classroom. This provides the support the student needs without requiring individual teacher time. One teacher also stated that she finds students tend to be more willing to ask questions to their peers than they are to ask her the same question. Another teacher mentioned that she always has mixed ability grouping to ensure that there is a benefit to all students.

One teacher talked deeply about this being an accommodation she uses frequently among all of her students. She said that she pairs students with those they are comfortable talking to and feel that they trust. There have been several times where this has formed strong bonds among her students. She has seen students answer questions for their low-level reader partner before the student has a chance to ask the question. This shows that this method is not only effective for its purpose, but also has some underlying classroom benefits.

Teacher reading material to the student

Three teachers talked about reading the mathematics material to the student as being one accommodation for low-level students in their mathematics classroom. This involves the teacher reading directions, problems, and all other necessary material to students. Teachers said this was typically done as a class, but can also be done a one-to-one basis.

One teacher talks about how she reads the directions to her students then makes sure they understand the material that was read. This goes beyond what the other two teachers mentioned by also ensuring understanding. By doing this, the teacher then can ensure that she is assessing the student's knowledge of the topic, not if the student is misunderstanding the expectations.

Discussion

All six of the teachers that were interviewed said they used literacy in their mathematics classroom in some way. In this, we see that there is a connection between the two concepts. We also see that there are several different ways that teachers accommodate their low-level readers. It can be assumed that teachers use discretion about an accommodation and whether it will work for their individual student.

Dodeen, Abdelfattah, Shumrani, and Hilal (2012) said teachers should be prepared to teach all mathematics topics. Through data collections, you can see that teachers are coming across several different levels of students that require a diversely educated teacher. If the teacher didn't understand all topics that make up mathematics, then they are not able to help their students. A low level reader could be a low level

mathematics student because of their reading ability. The teacher has to be able to teach that student material that would further their understanding.

Obara and Sloan (2009) conducted a study that looked a school implementing a new curriculum. That study showed that teachers need time and resources to make the full switch to the new curriculum. One resource that Obara and Sloan talked about was Math coaches. The teachers did not talk about having inadequate resources nor did they talk about math coaches. This leads one to consider whether that would help low-level students in mathematics classroom. If teachers would be given extra resources and specialized personnel to aid these students, would the teachers see increased in overall performance within students?

Cummins and Stallmeyer (2011) studied students that read a text aloud and the same students reading a text independently. The students read aloud with finer details than independently. When students were taught to synthesize text, they were able to better understand the text. Using this knowledge, it can be assumed that the same strategy could be true in mathematics. When students are taught how to synthesize text within their partner groups, students could have a better understanding of word problems and mathematics stories. Teachers explicitly talked about reading a text of some kind, a word problem, a mathematics story, directions, graphic organizers. With further instruction not only in traditional reading to further the students understanding, but also explicit instruction on synthesizing text could help low-level students excel more in their mathematics class.

Georges (1929) identified six types of reading difficulties within mathematics. These difficulties can be seen in the research participants' classrooms. Teachers talked mainly about the students with the difficulty that Georges describes as a lack of intensity of reading which is not being able to read the material and understand the full text, but they also talked about what Georges calls a lack of precision while reading and a difficulty that stems from the way that the problem is worded. These difficulties were mentioned and teachers talked about accommodations without reading the research, which proves Georges' main findings to be true even within a small, rural Elementary school.

A difficulty that seemed very minor to the teachers, but was still mentioned was students not understanding and interpreting a statement which involved vocabulary. Two teachers talked about this being a way that they use literacy in their classroom as well as a way that they accommodate for their low-level readers.

Vukovic and Siegel (2010) showed a small portion of the long term effects of low-level reading in mathematics classrooms. The persistent mathematics difficulty group tended to have mathematics difficulty because of their reading difficulty. Lin, Morgan, Hillmeier, Cook, and Maczuga (2013) found similar results in that students with mathematics difficulties while in the third grade had a 5.14 times higher chance to tend to also have reading difficulties in the fifth grade than those students that did not have reading difficulties. These two studies show that the difficulties tend to coincide with one another. In the current study, it can be seen that struggling readers are struggling in

mathematics in every grade level. There was a teacher that had the same students in second and fifth grade that had the same difficulty in both grade levels.

Harlaar, Kovas, Dale, Petrill & Plomin (2012) main findings stated that mathematics is more closely linked to reading comprehension than word decoding. Reading comprehension doesn't mean word decoding to Harlaar et. al. This is significant to the current study because students can decode some words, but if they are not in the context of mathematics terminology, then they are meaningless. If a low-level student has difficulty with reading comprehension, then they would need the accommodations that the teachers are providing. They would need to have teachers checking for understanding and not just telling the students the words that they do not know.

Kyttälä and Björn (2014) has the strongest connection to the current study because the researchers said, "both technical reading and reading comprehension were strongly associated with mathematics word problem skills" (p. 62). The most frequently way that teachers use literacy in their classroom is through word problems or mathematics stories of some kind. Kyttälä and Björn as well as the participants of this study show that a strong connection between reading and mathematics exist through mainly word problems and mathematics stories.

Conclusion

One way that the current study can be furthered is by involving students' perspectives on literacy in mathematics, as well as accommodations that they feel help them the most. This could help further the understanding of the connection as well as add to the list of resources available to teachers.

The current research not only adds to the confirmation of the connection between reading mathematics, but it also helps teachers understand ways that we can help our students. This is a task that is expected to be achieved every day that instruction is conducted.

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