

The impact of storybooks on kindergarten children's mathematical achievement and approaches to learning

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Abstract: This paper presents a mixed methods study that explored how storybooks influence kindergarten children's mathematical achievement and approaches to mathematics learning. Teachers' observations and research stating primary grade children's lack of mathematical knowledge and negative attitudes towards mathematics served as the impetus for the study. Three kindergarten teachers taught a mathematics unit using various children's storybooks and the characters in the stories as the context for mathematical problems. The results of the study show an impact on students' mathematical achievement as well as the identification of four themes that emerged on how students' approaches to learning were influenced when storybooks were integrated into the mathematics unit.

Key words: mathematical achievement; mathematical attitude; storybooks in mathematics

Young children exhibit interest in mathematical thinking long before they enter school. Although the accuracy of their reasoning is affected by developmental gaps in important thought processes, such as the ability to think about conservation of matter or skillful capacity to hold more than one concept at a time in working memory, young children eagerly attempt to approach problems with mathematical thinking (Copley, 2000). However, teachers report that children in kindergarten often express a dislike of mathematics, have anxiety over mathematics, and have a self-evaluation that they are not competent in the subject (Baroody, Lai & Mix, 2006; Hong, 1996; Wilburne, et al., 2007). Moreover, researchers report that anxiety influences physiological changes that can lead to decreased learning achievement (Ankay, 1990; Baltas, 2004; Oluk, Ozlem & Sakaci, 2009). These behaviors often lead to students developing negative attitudes towards mathematics and a fear of mathematics.

Marilou Hyson, former president of NAEYC, noted that young children who learn well demonstrate both enthusiasm for learning and engagement in learning (Hyson, 2008). Both the National Council of Teachers of Mathematics (NCTM) and the National Association for the Education of Young Children (NAEYC) have noted the importance of providing mathematics instruction in ways that motivate and excite young learners to enjoy mathematics and eagerly engage in mathematical thinking and problem solving (NCTM, 2000; NAEYC, 2002). Hence, the experiences and types of instruction which students are exposed to can impact their learning of mathematics and their attitudes towards mathematics.

Storybooks have been suggested as one resource to be used to help young children make connections between mathematics in the classroom and mathematics in life-like situations (Hong, 2000; Whitin & Whitin,

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2004). The purpose of this study was to understand how storybooks might influence both achievement of learning objectives and positive approaches to mathematics learning in three kindergarten classes. The research questions were: How was student achievement influenced in a mathematical unit taught through storybooks? How were student approaches to learning influenced when storybooks were integrated into a mathematics unit?

1. Theoretical framework

This study was framed as an implementation quality evaluation as described by Patton (1990, p. 109), "Quality has to do with nuance, with detail, with the subtle and unique things that make a difference...". In this case, the nuances and details of children's achievement of objectives and also of their attitudes and approaches to learning were explored in a mathematics unit in which storybooks were integrated.

1.1 Mathematical confidence

Over several decades, researchers have found an alarming trend in young children's relationship to mathematics. Baroody, Lai and Mix (2006, p. 211) report "a stark contrast" between children's mathematical knowledge before they enter kindergarten and after they have completed several years in primary grades. A corresponding contrast has been described between the mathematical confidence that children exhibit when they enter kindergarten compared with the lack of mathematical confidence and feelings of fear described by children by third grade (Ho, et al., 2000; National Research Council, 1989).

The traditional methods for teaching young children mathematics have been identified as antithetical to foster positive attitudes about mathematics and ineffective in facilitating meaningful mathematical literacy (Baroody, Lai & Mix, 2006; Hong, 1996). In the 21st century, it is important for teachers of young children to target instruction to facilitate mathematical achievement and also foster positive approaches on learning mathematics (Ginsburg & Golbeck, 2004).

1.2 Mathematical achievement

Teacher efforts to provide young children with mathematical achievement opportunities have been enhanced by the identification of standards and focal points published by NCTM (2000, 2006), and embraced by NAEYC (2002). These identified standards and focal points provide clear achievement targets for children, parents, and teachers. However, teachers of young children report problems in designing mathematics instruction in ways that enhance children's mathematical confidence and achievement (Wilburne, et al., 2007). Alternatively, teachers with identified pedagogical problems may actively choose professional behaviors that focus on "reflection as a given" and "practice-specified acquisition of pedagogical knowledge and thinking" (Mrazik, 2009, n.p.).

Upon examining research about the actions, characteristics, efforts, energies, tendencies and traits that children demonstrate when they learn, Hyson (p. 15) reported that effective learners are "enthusiastic about learning". She explains that successful learners show interest, curiosity, pleasure and motivation while they are learning. In addition, Hyson reports that effective learners are actively "engaged in the learning process" (p. 15). She explains that engaged learners demonstrate attention, flexibility, persistence and self-regulation to the learning process. Therefore, teachers who wish to enhance the quality of their children's mathematical achievement may decide to design instruction in ways that foster young children's enthusiasm, interest, pleasure, engagement, attention, flexibility, persistence, and self-regulation.

Reading literature with mathematics concepts is one strategy recommended to teachers to promote children's enthusiasm and interest in mathematics (Ducolon, 2000; Whitin & Whitin, 2004). This study is in response to a

call for research that examines the influence of incorporating children's storybooks on children's mathematical achievement and attitudes (Hong, 2000).

2. Methodology

The purpose of this study was to understand how storybooks might influence both achievement of learning objectives and positive approaches to learning mathematics in three kindergarten classes. This study was designed as a mixed-method investigation. Quantitative measures were used to compare student achievement of specific learning objectives before and after instruction. Qualitative measures were used to understand student thoughts, feelings, and attitudes throughout the unit.

2.1 Participants

Participants were three kindergarten teachers and their students ($n=70$) from three school districts in an urban, rural, and suburban setting in Central Pennsylvania. All three kindergarten teachers had expressed concern about finding time to offer quality mathematics instruction to the new state standards in ways that inspired positive student attitudes. The researchers introduced the teachers to each other in a meeting on campus, and the teachers recognized the common nature of their curriculum and motivation problems. Subsequently, several meetings occurred with the three teachers and researchers discussing possible mathematics units to base the study. The decision was made to focus on a unit of study related to money. A second decision was made to read storybooks with mathematical content related to money to the children each day. The learning objectives related to recognizing coins, knowing the value of each coin, simple addition of coins, and problem solving with money. The teachers asked the researchers for help in finding appropriate books, developing probing questions, and creating problem-solving scenarios that would involve the children in mathematical thinking where the story book characters would pose problems.

2.2 Data collection

Data were collected with pre- and post- tests of children's mathematical knowledge of money, surveys of children's attitudes, classroom observations, audio-tapes of story book reading and discussions with children, pre- and post- study interviews with individual teachers, and group discussions with teachers. Documents collected included: student written and drawn work in response to problems; photographs of classroom centers; teacher journals and researcher journals; survey results; and interview and focus group transcripts.

2.3 Data analysis

Data were analyzed for answers to the research questions. The answer to the first research question was determined by a statistical analysis of pre- and post-test scores. The answer to the second research question was determined by a thematic analysis of student and teacher documentation, surveys, interviews recordings and documents. Teachers and researchers analyzed data individually and together. The constant comparison method (Strauss & Corbin, 1998) was used within repeated readings of the data. Individually, the researchers noted potential themes and reasoning. Together, the researchers discussed the importance and relevance of each potential theme to answer the research questions.

3. Results and findings

The results of the quantitative portion of this study are reported in a statistical analysis related to the first research question. The findings of the qualitative portion of this study are reported in four themes related to the

second research question.

3.1 Research question 1

The first research question asked: how student achievement was influenced in a mathematical unit taught through storybooks. Comparison of pre- and post-test scores from the unit assessment showed children who began the unit with little knowledge of coin recognition and coin value had achieved all three objectives. The mean scores on the pretest were 11/25, with a standard deviation of 1.5, while the mean scores on the post-test were 21/25, with a standard deviation of 2.1, indicating significant development of knowledge in three weeks. The scores provide evidence that time taken to read and discuss storybooks did not detract from student achievement of the mathematical objectives.

3.2 Research question 2

The second research question asked: how student's approaches to learning were influenced when storybooks were integrated to a mathematics unit. Thematic analysis of transcripts yielded four themes: (1) a sequence of children's mathematical problem-solving development, (2) use of child imagination regarding mathematical thinking, (3) a pattern of child involvement with mathematical concepts and processes, and (4) evidence of Hyson's framework of approaches to learning.

3.2.1 Theme 1—Sequence of children's mathematical problem solving

The first theme revealed that storybooks prompted children to move through a sequence of mathematical problem-solving steps. The first step of this sequence was labeled: Character-Posed Problems. In this phase, the children used mathematical thinking to help the characters in the story solve problems. For example, the children in all three classes posed mathematical questions related to the main character in Benny's Pennies (1995). Children in one class posed the following mathematical questions: (1) If Benny had ten pennies, what could he buy? (2) How many pennies would he need if he bought a present for himself too? (3) "If he lost a penny, how much money would he have?"

The second phase of the sequence was labeled: Teacher-Posed Problems. In this phase, children used intentional mathematical thinking with teacher-assignment activities and discussions. For example, on the day that a teacher asked if Benny would rather have one dime or five pennies, the children enthusiastically entered into the confusion of learning about coin value when size and value are not correlated. The teachers all expressed surprise at the contrast between child interest in searching for answers when the questions related to Benny compared with questions posed in the mathematics lesson. One teacher noted when she posed coin value questions related to Benny and his pennies, the children "eagerly shouted out answers, explained their reasoning, and demonstrated continued interest in the subject even when their reasoning lead them to inaccurate answers". This same teacher's journal noted that she had been teaching "basic skills of coin recognition in the mathematics lesson for six weeks with little success".

The third phase of the sequence was labeled: Student-Posed Problems. In this phase, children used mathematical thinking to make connections in their learning centers and in their own lives. For example, at the mathematics learning center, children pretended to be Benny by matching, exchanging, questioning, and finally coming to understand that "the little one is the dime—the same as 10 pennies". Day after day, the children worked with the characters in the books to play with and figure out coin value. Moreover, in one class, as the children played in the pretend store with the pretend cash register, one teacher's journal notes indicate that her children were challenging themselves to count five pennies or ten pennies to match the nickels and dimes that other children brought to the pretend store.

3.2.2 Theme 2 —Use of child imagination regarding mathematical thinking

The second theme identifies ways that storybooks influenced children's use of imagination in ways that fostered their mathematical thinking development. At first, children spoke of the storybook characters as if they were real. As the unit continued, the children brought the storybook characters into their pretend play and thinking, so if the character had a problem, the children wanted to help solve it. To solve the character's problem, the children guessed, estimated and created out-of-the-box solutions as well as strategic ways to solve the problems. During group discussions and at learning centers, the children talked, argued, and defended their approaches. Often, their solutions combined imaginative and realistic ways of thinking. Gradually, over several weeks, they moved into realistic mathematical problem solving using strategies such as guess and check to solve problems.

The book, *Minnie's Diner*, engaged the children in thinking about many mathematical concepts simultaneously. As successively larger members of a family entered the diner, the children noticed size differences, the amount of food ordered as well as the cost of the food. "Look at that shadow! That guy sure is big! Look how much food he eats!" exclaimed a child in one classroom. A few days later, the children began to pretend that they were in the diner, and they used the trays, dishes, coins, and cash register to work out prices and coin value problems. In response to a writing prompt, children demonstrated that they had begun to identify with the story characters. One child wrote about his role as the waiter and showed his ability to balance a tray with "lots and lots of food and the food was all cherry pies". Many children wrote about their roles as customers who could order anything they liked, "16 popcorn and 17 drinks" or "100 peanuts and milk". One child identified with the store owner, "We are open. We have red chairs". Later, when the children talked about coins and drew marks to represent how many cents each coin represented, they were doing so, not as a random exercise, but as persons who needed to know about coin value to succeed in their pretended self-assigned role. When the children wrote in their number books what they would buy for one cent, two cents, five cents, and twenty-five cents, they had practiced considering relative value of items. They had begun thinking about coin value within their pretend worlds through the use of their imaginations, and had concluded the unit by thinking about coin value within their real worlds through the use of realistic thought.

3.2.3 Theme 3—Pattern of involvement

The third theme shows that storybooks influenced specific patterns of child involvement with mathematical thinking throughout the unit. Children engaged in dramatic play with the story characters, contexts and problems. They drew pictures to represent the mathematics within the story and within their own dramatic play scenarios. With teacher guidance, they wrote and illustrated mathematical stories of their own, and they narrated their stories in small groups. As the unit progressed, the children generated increasingly complex problems and made connections to other disciplines.

The children in all the classes responded to the book, *A Chair for My Mother*, with audible emotion. "They gasped at the page with the fire", reported one teacher. In the dramatic play center, fire persons accompanied by screaming sirens arrived frequently after this book was read. After the fire, the characters in the book work together to save coins in a large jar with the goal of purchasing a beautiful and comfortable chair for the hard-working mother to enjoy after her day of work. The children in the classrooms wrote and illustrated stories about what one gift they would like to buy their mothers. "Lots of earrings", "lots of flowers", "the same chair as the book", "a big rig", and "a mansion for my whole family to live in", were some of the children's answers. Following discussions of relative value of things, the children drew the number of coins their gifts might be worth. As the children narrated their stories about mother gifts, children in each classroom asked questions and made comments indicating their awareness of concepts as "not enough money", and "needing to get a job to get more

money”, and “saving money in a bank so later there is lots more to buy a truck”. Interdisciplinary mathematics and social studies discussions continued for many days according to all three teachers.

3.2.4 Theme 4—Evidence of Hyson's framework of approaches to learning

The fourth theme revealed that the children in all three classrooms related to the storybooks with each of the approaches to learning identified in a recent review of literature (Hyson, 2008). As classroom discussion moved from the story to related mathematics, the children persisted in demonstrating each of the characteristics of enthusiasm (interest, pleasure, motivation) and engagement (attention, flexibility, persistence, self-regulation).

The children's comments and questions during the reading of each storybook pointed out that they were “enthusiastically interested” in the storybook characters and “actively engaged” in making meaning of the story actions and contexts. Further, the children “enjoyed” imagining about the story as it was written and also as the children themselves re-imagined. Researcher notes mention that when mathematical concepts were connected to the characters, the children “happily” thought about the concepts. Simultaneously, the children maintained “interest” in the characters and the related mathematics activity over a period of time. Even when achieving understanding that was difficult and required persistent effort, the children continued to talk, manipulate materials, ask questions and struggle for comprehension. Paradoxically, the children demonstrated ability to be “flexible” enough to comprehend mathematical concepts that were opposite of their original mental model, as they also had to maintain enough “persistence” to keep putting forth effort to comprehend. All through the unit, the children maintained enough delayed gratification, “self-regulation”, to stay with the task of constructing new knowledge. Sharing this paradoxical activity with well liked characters in the books seemed to help the children stay with the work.

To summarize, the children enjoyed the unit with enthusiasm and engagement with the characters in the storybooks. In response to the mathematical problems about the characters posed by teachers, the children demonstrated enthusiasm and engagement in solving the problems, using mathematical thinking in a natural way. Further, as the unit continued, the children began to pose mathematical problems related to the book's characters, their learning center activities, and their own lives outside the classroom.

4. Conclusions

The purpose of this study was to understand how using storybooks might influence both children's achievement of learning objectives and also children's development of positive approaches to learning mathematics in kindergarten. While children were imagining storybook scenarios in which the characters were struggling with problems, the children used mathematical thinking as a natural way of helping. With each imagined discussion, the children were constructing mathematical knowledge and honing mathematical skills in ways that assured both achievement and positive attitudes and approaches to learning mathematics.

5. Educational implications

Characters in stories may provide young children with the kind of playful learning opportunities that Vygotsky (1978) described as essential to child learning in any content area. Preservice and inservice teachers may benefit from building a library of books and creating a collection of related mathematical problems to pose and mathematical activities. Teacher educators may consider designing class sessions with experiential opportunities to compare worksheet mathematics instruction with storybook problems posing ways so that preservice and inservice teachers can sense the difference between right-answer mathematics and the inquiry of

imaginary-character mathematics.

The results of this study may encourage teachers of young children to consider the importance of adding multiple readings of storybooks to content subjects. If the story characters and contexts provide young children with elements of instruction that invite enthusiasm and assure engagement, the expenditure of class time is warranted. Another implication of this study may be related to the benefits of integrating mathematics, literacy, and social studies instruction around characters in stories.

Further research is needed to report additional strategies for connecting storybook characters and contexts to other content areas to activate enthusiastic engagement in learning. At present, the field of early childhood education is searching for multiple ways to offer intentional content learning opportunities to young children. Therefore, researchers could investigate strategies for enhancing children's interest, pleasure, motivation, attention, persistence, flexibility and self-regulation as story characters explore science, social studies and the arts.

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