Integrating Mathematics and Literacy in Early Childhood Teacher Education:
Lessons learned

By Kay A. Wohlhuter & Elizabeth Quintero

Kay A. Wohlhuter is a professor with the Department of Education at the University of Minnesota-Duluth, Duluth, Minnesota, and Elizabeth Quintero is a professor in the Department of Teaching and Learning at the Steinhart School of Education at New York University, New York City, New York.

Introduction

During the 1998-1999 academic year, our state board of teaching changed the licensure configurations in early childhood from Birth to Age 5 to Birth through Age 8. This made early childhood teacher licensure commensurate with the National Association for the Education of Young Children's recommendation that an early childhood program is any group program in a center, school, or other facility that serves children from Birth through Age 8. Historically, our early childhood studies program at a small university in the Midwest has prepared students to work in child care centers, family-child-care homes, Head Start programs, private and public preschool, and parent education and community education programs. We needed to expand our pro-

gram to prepare students to work in kindergartens and primary grade schools. The movement to a new program meant that education licensure students in their last year of teacher preparation had content and practice in the area of Birth to Age 5, but still needed the Age 5 to Age 8 content information. We developed and implemented a special course in the summer of 1999 that addressed mathematics and literacy Kindergarten through Grade 3. We then used the experience of implementing this course to guide our development of the Birth to Age 8 mathematics and literacy course for the new licensure program. This article reports our thoughts, struggles, expectations and surprises as we describe our backgrounds, planning for the course, implementation of the course, preliminary findings, implementation of subsequent courses, conclusions, and implications. We share these ideas from a new experience in hopes of fostering discussion and thought about content learning in early childhood courses.

Instructors' Backgrounds

I, the first author, brought the mathematics education background to the project. I have liked mathematics for as long as I can remember. I pursued teaching mathematics because I felt that I had the ability to explain mathematical ideas clearly to people. Over the years as I developed as a teacher, I discovered that explaining mathematical content clearly to students was not enough for them to understand mathematics. Students learning mathematics by listening may explain why so many people proudly claim "I was never good at mathematics" when I tell them I am a mathematics teacher. Learning by listening also does not prepare students to meet the overall goal of mathematics education: to become mathematically literate. The National Council of Teachers of Mathematics (NCTM, 1989) defined mathematic literacy as "an individual's ability to explore, to conjecture, and to reason logically, as well as to use a variety of mathematical methods effectively to solve problems" (p. 6). Due to the information age in which we live, students need to be mathematically literate to be productive citizens in the twenty-first century (National Research Council, 1989; Sowder 1989; Van de Walle, 2000).

Research involving the nature of mathematics, how children learn mathematics, and the role of the teacher during reform implementation influences how I organize and implement my mathematics methods courses. Research about the nature of mathematics shows that teachers' conceptions of mathematics influences how they approach the teaching of mathematics (Dossey, 1992; Thompson, 1984; Wohlhuter, 1998). Research involving children learning mathematics emphasizes the importance of children being physically and mentally active in the learning process (Battista, 1999; Kamii, 1985; Kamii & Ewing, 1996; McClain & Cobb, 1999). As indicated by research involving implementation of mathematics reform, the teacher plays a major role in determining what mathematics and how the mathematics will be addressed in the classroom (Ball, 1992; Cooney, 1988, Ferrini-

Mundy & Johnson, 1996). Thus, I provide preservice teachers with many opportunities to experience mathematics while examining their definition of mathematics and their role in the teaching and learning of mathematics.

I, the second author, brought the literacy background and interest to the planning and teaching process. A little of my past experiences, including both formal and informal education, reveal personal assumptions that influence my decisions in curriculum and teaching. I was still learning about culture, language, teaching and learning during the decade I lived in Mexico, where my three sons were born. After a few years, I went to New Mexico to work on a doctorate in early childhood/bilingual education. This was when Yetta Goodman and others — during the beginnings of the whole language movement — spoke of young children's play and communication as exemplifying the "roots of literacy." I realized that I had been studying and observing first hand these roots of literacy in the three- and four-year-old children I had been working with for years. Literacy develops in an intricate dance of personal and communal meaning, content of what is being communicated, and the process of how it is communicated.

My first teaching position was in a small preschool for three- and four-year-old children. After I finished my Masters in Education/Early Childhood Studies, I expanded my work to kindergarten teaching. It was during this chapter of my life that I became very involved in asking the question, "what's left out...of my personal experience, of my education and ultimately my teaching?" This was the beginning of the conviction about which I talk now when I tell students to always ask the questions about whose stories and opinions are left out of every text book, every research study, and every news report. I was becoming a critical pedagogist and developing the perspectives and commitments that would lead me in the directions that guide my work today.

Some of the research in literacy development and curriculum that has been important in my teaching and research can be categorized into basic principles that I pass on to my students regardless of the age/grade level of students with which they are working. Research in reading and literacy development (Harste, Woodward, & Burke, 1984; Smith, 1985, Taylor, 1998) emphasizes the importance of social context and the learner-centered nature of literacy development. The holistic approach to the acquisition of literacy skills has been proven to be most effective. Much has been written recently about learning language holistically, within a natural social context, as opposed to breaking it down into segments which are unnatural (Cummins, 1981; Freeman & Freeman, 1998). Research in second language acquisition and biliteracy development echoes this demand for developmental programs that emphasize learner autonomy (Auerbach, 1989; Goodman, 1996; Weinstein-Shr & Quintero, 1994). This is especially important for preservice teachers to understand since by the year 2030 more than half of the learners in the schools will represent cultural and linguistic diversity due to the demographic changes in all communities across the country.

Initial Planning

Planning for this combined course meant discovering how the two of us — a mathematics education specialist and an early childhood, multicultural, families specialist — could work together to merge our philosophies and address our subject areas in the context of a one-week, three credit course. We were in agreement about using constructivist-based instruction. Mathematics is best learned through instruction that provides students with opportunities to investigate mathematical ideas, interact with each other, and connect mathematics to the world around them. Literacy development is enhanced by early childhood teaching that combines an interactive classroom structure, use of children's literature, and hands-on learning activities which can be adapted for content requirements for kindergarten to grade 3 teaching. Through constructivist-based instruction with carefully planned content, we provided the preservice teachers with opportunities for experiencing mathematics and literacy appropriate for kindergarten-to-grade-3 students, and in the process, modeled instruction for their classrooms.

We also realized the need to help our preservice teachers recognize how their early childhood work with mathematics and literacy related to and provided a foundation for future work as kindergarten-to- grade-3 teachers. Thus, preparing them for a setting traditionally more structured and content- focused than some early childhood settings. Previously, our preservice teachers worked with the mathematical ideas of classification, seriation, and number as a small part of a cognitive and social skills course. This minimal exposure to mathematics meant that our students needed opportunities to learn that mathematics also included geometry, data investigation, probability, and measurement concepts and problem solving, reasoning, and communication processes. Preservice teachers' experiences with the multifaceted nature of mathematics would help them realize how classification, seriation, and number fit into the overall scheme of mathematics and recognize that the geometry, data investigation, probability, and measurement expectations for kindergarten to grade 3 students had their beginnings in early childhood play activities.

Our early childhood candidates' literacy experiences addressed the importance of activities for children that encouraged social, emotional, and cognitive development. In previous courses, our students designed and implemented theme-based activities for young children in various curriculum areas and were familiar with children's literature and concrete, hands-on, learning center activities. In designing the new course we included more of the research-based strategies that support literacy development in kindergarten through third grade.

Even though we had separate subject-area agendas, we were committed to integrating literacy and mathematics. The emphasis both of us put on communication provided the vehicle for doing the integration. The literacy focus on the multiple components of reading and writing processes is probably what people expect to happen in a literacy course. It may be a surprise to some that the processes

of reading and writing are equally important in the area of mathematics. Mathematics as communication is one of five processes emphasized in mathematics education reform. To be mathematically literate, students need to develop and express their mathematically thinking through reading, listening, drawing, giving oral explanations, writing descriptions, using tables and charts, and using manipulatives (NCTM, 1998).

A desire to extend our students' previous early childhood work and to provide a strong model of integrating mathematics and literacy guided our selection of learning stations as a course organizer. We used the phrase "learning stations" to describe a set of activities that revolved around one theme, addressed the same mathematics concept, and included a variety of literacy strategies. As an instructional strategy, the use of learning stations enables a teacher to implement a cohesive, more subject-area-focused series of activities. For example, we designed a station for second graders around the book *One Hundred Hungry Ants* (Princzes, 1999). One student read the book to their small group. Students retold the story by writing a version in their own words and illustrating their work. Students demonstrated the arrangement of ants in different groups with color tiles and then applied this knowledge to a new grouping of ants.

A one-week, three-credit course meant that we needed to immerse our students in mathematics and literacy as they synthesized new information and applied it to real children. In this context, we focused our instruction on seven- and eight-year-old learners in order for our students to understand the whole age spectrum of the early childhood focus of their license as they concentrated on the level most different from their previous experiences. It is also important to state that we addressed issues for five-and six-year-old learners during discussions that extended our classroom activities.

Implementing a One-Week Course

Our general approach to the week was that each of us had two blocks of time each day to address our respective subject-area agendas and that we led the discussions together when we focused on integrating mathematics and literacy through station work on days one and five. Each of us stayed in the room when the other was teaching in order to learn from each other, look for opportunities to make connections between the two areas, and chime in about that connection when the teachable moment arose. Descriptive highlights from the first two days of class illustrate how we implemented our course by using the idea of "what do they know; what do they need to know" to guide our instruction.

Students' initial definition of mathematics focused on numbers, operations, and sorting, suggesting a narrow view of mathematics. I, the first author, challenged students to broaden their definition as they experienced mathematics through a problem-solving approach. I defined the problem-solving approach as one in which

students engaged in the learning process physically through the use of models and mentally through the use of reasoning. Students explored mathematical content such as probability, area, graphing, patterns, and number sense as they worked with colored tiles, spinners, pattern blocks, and cuisenaire™ rods. Through individual reflections, small-group discussions, and large-group discussions, students continually answered the question "What is mathematics?" Connecting the activities and mathematics to the content and process ideas presented in *Principles and Standards for School Mathematics: Discussion Draft* (NCTM, 1998) and our state mathematics framework was another important component of class discussions.

The mathematics part of Day 2 began with students watching a video of elementary classrooms in which teachers guided student exploration of various mathematics topics with pattern blocks. Class discussion of the video focused on identifying the mathematics in the activities, the role of the students and the role of the teacher in the lessons, and the connections between the mathematical processes and actions in the video. My students continued to build their knowledge about the teaching and learning of mathematics as they explored number relationships, concepts of addition and subtraction, and connections between children's literature and mathematics. In addition, my students discussed the decisions teachers make to implement constructivist-based instruction in their classrooms.

The first day's literacy focus was on students' applying through problem-posing activities previously learned birth-to-age-5 literacy ideas to seven- and eight-year old learners. I, the second author, defined the problem-posing activities as a three part process in which students reflect on information, participate in a dialogue about the information, and then engage in hands-on application of the information. In the morning session through this problem-posing series of activities, students examined Cambourne's conditions" (Pike, Compain, & Mumper, 1997) for literacy development. Cambourne's Conditions included the following ideas: (a) immersion in written medium, (b) demonstration of how print medium is used, (c) expectations "given off" by teacher to class, (d) responsibility for own learning, (e) approximation: franchise to "have a go," (f) practice: employing the developing skill, and (g) response: mutual exchanges between experts and novices. As my students connected characteristics of seven- and eight-year-old learners with the various categories, I wanted them to realize that Cambourne's idea to apply previously tried-and-true principles of oral language acquisition to literacy acquisition was considered radical at the time, but is now considered sensible and replicable as good literacy practice.

In the afternoon session building on classroom conditions for developing literacy and using the problem-posing process, students examined an integrated approach to literacy through reading ideas from Pike et al. (1997) and Krashen (1999) and watching videos of preschool and elementary classrooms in which the whole language approach was used. To complete the three-part problem-posing process and to set the stage for the next day's discussion, I directed students to record

in their journals thoughts about the following ideas: (a) framework for a writing program, (b) stages of writing process, and (c) three modes of reading.

To start Day 2 individual students labeled their journal thoughts about writing as old information, new information, and information especially relevant for seven- and eight-year-old learners. As my students connected their previous knowledge with new knowledge, I guided the discussion to emphasize ways to support reading and writing, including shared reading, paired reading, sustained silent reading, and language experience approach. I also wanted teachers to know ways to support and scaffold writing, writers' workshop, conferencing, and publishing. Finally, I wanted teachers to know content in terms of appropriate materials such as stimulating children's literature, trade books, nonfiction books, manuals, letter writing materials, and mural materials. As a group, students discussed their labeling and used the ideas to analyze the previous day's station work.

Class discussion continued as we addressed the three types of literacy programs: (a) traditional, (b) transitional, and (c) whole language. Students examined these three programs by identifying main ideas, critical questions, and ideas related to seven- and eight-year-old learners. Group discussions focused on connecting literacy program ideas with previous class activities. Students applied their knowledge of literacy teaching models by analyzing and discussing a classroom video.

Instruction for Days 3 and 4 was similar to the format previously described since we tried to continuously model constructivist-based instruction. The mathematics content included concepts of multiplication, shapes, area, patterns, and fractions. The literacy content consisted of language experience stories, reading workshop, literature circles, writers' workshop, journal writing, and writing across the curriculum. On Day 5, students engaged in activities designed to summarize course ideas and demonstrated their application of knowledge in presentations of their group-created integrated stations.

Preliminary Findings

The purpose of this project was to expand our early childhood program by designing a course that integrated mathematics and literacy and met the needs of teachers of kindergarten through age 8 students. This course represented our first attempt at combining these subjects and at working together. Our reflections on the planning and implementation of this course generated ideas about subject areas, instructional strategies, ourselves, and our students that influenced how we taught the birth-to-Age 8 course in the following years and will provide information for other early childhood educators.

As we planned the course, we knew our respective emphases on communication provided the vehicle for integrating mathematics and literacy. We had not realized that other commonalities strengthened our approach for helping students see the connections between mathematics and literacy. One aspect of both subject areas was

that mathematics and literacy ideas are everywhere in young children's lives. This means children come to school with initial ideas about doing mathematics and literacy. Be it sorting blocks, dividing a candy bar equally, drawing pictures, or reading cereal boxes, young children are experienced mathematicians, readers, and writers when they enter kindergarten.

Both subject areas contained a component labeled "basics skills" and identified as a concern by reform critics. In the area of mathematics, these basic skills are known as mastering the operation facts. For literacy, these skills usually include as phonics, spelling, and grammar mechanics. As we addressed our respective basic skills, we found ourselves giving the same message: the basic skills were one component of the subject area, but they did not define the whole subject. In addition, the emphasis was on how children learned these skills in constructivist-based instruction. Our preservice students more readily understood the role of literacy basic skills in a whole language curriculum. We built on this understanding by challenging them to think about operation facts as part of a "whole mathematics" curriculum.

The authors' discussions of the commonalities generated suggestions for instruction, reinforcing the idea that we cannot truly separate what we teach from how we teach. Supporting this connection between content and instruction was the idea that children must *experience* mathematics and *experience* literacy in order to understand the content. Going into the course, we knew we agreed about using constructivist-based instruction, but we never talked about the specifics of how each of us would address content. In reflection, the similarities in our approaches were evident as we explained and modeled for our students a problem-solving approach to the learning of mathematics and a problem-posing approach to the learning of literacy. The processes used in both subject areas helped our students see the connection between the two subjects and the strengths of these critical methods.

Another lesson we learned form this experience was that we — a mathematics education specialist and an early childhood, multicultural, families specialist — could work together to develop a course that met both of our subject-area expectations. Each of us are strong advocates for our respective areas, and we had some concerns whether we could blend our ideas satisfactorily. As we taught the course and learned from each other, we realized that we implemented our constructivist-based instruction in ways that complemented each other. For example, the second author's use of families and their settings as a social context for learning literacy matched the first author's use of the home setting as a real world context for exploring mathematics.

In addition, another positive result of integrating mathematics and literacy was the opportunity for students to be more successful than in previous learning experiences. In particular, the mathematics medium empowered some of the weaker language arts students to show stronger literacy ideas as they demonstrated their understanding of mathematics. It was valuable for our students to see how they could be successful when they worked in an integrated setting.

While it was true that our students developed stronger literacy ideas and some of them flourished when examining together mathematics and literacy, it was also true that collectively our students needed more processing time than could occur in a one-week class. Students entered the course more comfortable with literacy ideas than with mathematics ideas. Our students made a good start with expanding their mathematical mind set; at the same time, this process was overwhelming for them. As some students worked to overcome this feeling of being overwhelmed about the mathematics, they forgot to illustrate what they knew about literacy. Therefore, we learned that the implementation of an integrated mathematics and literacy course needed to provide students with more processing time than can occur in a one-week setting.

Implementation of Subsequent Courses

The previously-discussed summer course provided lessons for the design and implementation of a 5-credit, semester, birth-to-age 8, mathematics-and-literacy course. Additional features of the semester course included extensive work in the field and a technology component. As part of an early childhood program initiative, each student had a laptop to use in courses and the instructors made a commitment to infusing technology in their courses. Our students used *MicroWorlds Pro* (LCSI, 2000) to create instructional programs that integrated mathematics and literacy. Discussions of pedagogical examples, assignments, and student work will highlight key components involved in integrating mathematics and literacy.

Knowing the basis of the course and having a semester to teach the course enabled us to better model the integration of mathematics and literacy during our instruction. One area in which this occurred was the use of children's literature books that contained mathematics content. When we used children's literature books to introduce mathematics concepts, we modeled literacy strategies during the lesson. For example, during the discussion of *Grandfather Tang's Story* (Tompert, 1987), students explored aspects of folk tale genre and created shapes using tangrams. *When The Doorbell Rang* (Hutchins, 1989) story was presented, students were asked to use the strategy of predicting what happens next in the story while being introduced to the equal-groups interpretation of division.

A second area in which we worked to make stronger connections between mathematics and literacy regarded the important role of language when learning different concepts. Precise language provided important scaffolding cues for concepts in both subject areas. For example, partners participated in a geoblock activity that required them to communicate with each other. One partner created a structure using geoblocks while the other partner looked the other way. The creator described the structure and the second partner tried to recreate the structure based on the descriptions. Our students discovered that the use of accurate mathematical language made it easier to describe their structure.

More time for presenting our stations and revised learning-station content enabled us to better model the integration of mathematics and literacy. As previously described, the learning stations were a set of activities that revolved around one theme, addressed the same mathematics concept, and included a variety of literacy strategies. Since this was a semester course, we waited to introduce the stations until mid-semester. This time line allowed us to spend several class sessions providing more foundational work in mathematics and literacy and to design and model integrated mathematics and literacy activities. In this set of stations, our students explored equal groups of multiplication through differing mathematics activities while engaging in various literacy strategies such as reader's theater, reader's workshop, writer's workshop, and writing and drawing electronically using *MicroWorldsPro* (LCSI, 2000).

Two groups of assignments in particular enabled us to better facilitate preservice teachers' proficiency in designing and implementing integrated curriculum. The learning station component was done in two parts. Mid-semester, in small groups, students created a set of stations for a chosen age group. Each group set up their stations for participation and feedback from the whole class and the instructors. Then, students chose a different age group for individually creating a set of station as a final project.

In addition to the usual preservice teachers' field work, such as observing children's interactions and journalling about observed instructional strategies, we asked our students to plan and use with their children an activity that integrated mathematics and literacy. Suggested activities included ideas such as reading a story book with a mathematics concept and then writing a dialogue journal with a classmate or choosing a real-world mathematics context and doing a writer's workshop mini-lesson.

Anecdotal evidence of student outcomes suggested that our approach to these courses impacted their development as teachers. As the course progressed students' confidence and comfort level with the subject areas became more evident. They shared their discoveries of real-world mathematics and literacy examples and recognized the potential for future lessons based on this knowledge. For example, a student talked about how she noticed the different shaped traffic signs and realized that her children should look for geometry in the real world. Specifically, she designed an activity where children went on a scavenger hunt in the neighborhood looking for geometric shapes and then writing a group language-experience story describing their findings.

Early childhood preservice teachers learn that children's conceptual development occurs in an integrated fashion. As the preservice teachers participated in our course, they became acutely aware of the need to provide children with integrated learning experiences to enhance this development. One student described in her journal her teaching experience about how using *Beep-Beep Vroom Vroom!* (Murphy, 2000) led to literacy and mathematics activities that encouraged inte-

grated learning. She was amazed at how students enthusiastically used writing and drawing to illustrate their own patterns for their first-grade-class pattern book.

Conclusions and Implications

The complex nature of the teaching and learning experience described in this article bring up challenges to consider when planning a similar course. The commonalities between mathematics and literacy which enhance integrating teaching are not evident to some educators developing curriculum. In other words, there are few available materials that integrate mathematics and literacy while focusing on subject matter specifics. Consequently, teachers need to seek out resources and create their own. Instructors also must be aware that the preservice teachers may not see in their field work the pedagogical approaches used in the course. This means that students will need more guidance and support for trying out ideas. If this course is taught in a team-teaching format, compatibility of philosophy and teaching styles is helpful in order to cohesively present the course.

Through the journey of developing these courses, we continually learned more about our respective subject areas while identifying connections between mathematics and literacy. We emphasized the content information needed by teachers of young children so that those teachers can model, provide experiences, and facilitate learning that focuses on communicating, asking critical questions, hands-on learning, and reflecting about how this learning endeavor relates to all of life's activities. The key to implementing our course was providing students with opportunities to be the type of learners that we hope their children will be one day. Even though we were addressing mathematics and literacy, it seems possible that the ideas we used to develop this course could also be used in developing other integrated content courses.

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