Building Kindergarteners’ Number Sense and Future Teachers’ Sense of Children: Software Tools from a College/Elementary School Partnership


Abstract

The authors participate in a college/elementary school partnership intended to enhance the quality of the teacher education program at the college and provide increased opportunities to individualize instruction for the elementary students. One component of this partnership is a project geared toward promoting the development of Kindergarteners’ numerical concepts. Software applications designed to complement the pedagogical goals of this project are presented, and students’ reaction to the software is discussed.
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Introduction

We are members of the Education Department at Augustana College in Rock Island, IL. Our institution recently formed a partnership with Longfellow School, a neighborhood elementary school primarily serving low income students. The partnership transitioned from its planning period to full implementation at the start of the 2009-2010 school year. Augustana education faculty are working collaboratively with Longfellow teachers and administrators in developing curricula and devising strategies for optimizing our partnership. Many exciting ideas are being put in motion, including the placement of all of our junior elementary education majors at Longfellow in order to support instruction in the school and apply the teaching techniques they are learning at Augustana.

Our specific interest within the larger partnership centers on early childhood mathematics instruction at Longfellow and how software applications might be used to support this instruction. The partnership provides an opportunity to both enhance the quality of our teacher education program at Augustana and to provide meaningful mathematics learning experiences for Longfellow’s kindergarteners. The required undergraduate course “Teaching Mathematics in the Elementary School,” which includes 32 enrollees, is being partially taught in the Longfellow building, providing pre-service teachers an opportunity to apply teaching methods with actual kindergarten students.

1 According to the 2008 Illinois School Report Card, available at http://webprod.isbe.net/ereportcard/publicsite/getReport.aspx?year=2008&code=4908104102015_e.pdf, 67.5% of Longfellow’s students are classified as “Low Income,” meaning students come from families receiving public aid; live in institutions for neglected or delinquent children; are supported in foster homes with public funds; or are eligible to receive free or reduced-price lunches.

2 Prior to the fall of 2009, these students have completed four education courses: Educational Psychology, Educational Assessment, Methods of Inclusion and Social Studies Teaching Methods. The Inclusion course includes a clinical component, so the students have had some direct exposure to working with elementary school students. The Assessment and Social Studies Teaching courses have exposed students to planning lessons and assessing learning. Hence, these students have a modest level of professional knowledge and experience as they enter their junior year. In our program, the junior year involves more extensive exposure to teaching methods and further clinical placements in schools.
Over the course of our fall trimester, pairs of Augustana students are required to prepare and execute lessons for triads of children on seven different occasions. The first lesson, taught in late August of 2009, was informed by data from a formal assessment administered to the kindergarteners by the researchers earlier in August. Subsequent lessons have been and will be informed by the undergraduate students’ informal and formal assessments of the children’s developing numerical competencies. Thus, the presence of 32 college students within the school is providing opportunities to individualize instruction for the children and help ensure that the learning needs of each child are met. We will continue to support the kindergarteners’ numerical development after the collegiate course is completed in November by hiring four undergraduates from within the course to continue working as assistants on the project for the remainder of the school year. While the number of college students working on kindergarten numeracy will decrease after our fall term, the assistants who remain with the project will devote more time to the work, thus maintaining significant adult support for the children.

We have developed a collection of software applications designed to complement the goals of the project, and have also funded the purchase of two computers for the Longfellow kindergarten classrooms, thus ensuring that the children will have the necessary hardware to operate our software. The software applications are intended to support the children as they develop age-appropriate numerical competencies. At the moment, this software serves as one of many tools used by our pre-service teachers as they tailor instruction to the needs of the children. As the number of Augustana students at the elementary school decreases in the near future, we anticipate that the software will continue to serve the kindergarten teachers and students. It should provide self-guided skill practice to students without necessarily requiring the presence of an adult. Indeed, given that the number of available “teachers” will drop, we anticipate that the regular kindergarten teachers will rely more heavily on the software as a means of individualizing instruction for their students. In this paper we share research which informed the development of this software, discuss how the software was developed, provide preliminary observations of how the software has been received by the children, and indicate future directions for our work.

**Review of Research**

Our decision to focus on the mathematical development of Kindergarten students is strongly informed by the research literature. Numerical concepts and skills developed before the first grade have been found to be a better predictor of future mathematical achievement than other early childhood tests of intelligence or memory abilities (Krajewski, 2005). Aunio et al. (2005) found that young students who fail to develop numerical skill beyond rote
counting are highly likely to encounter learning and teaching difficulties in the middle school and beyond. Clements & Sarama (2007) confirm that “accurate, effortless, meaningful and strategic counting is an essential early numerical competence,” one which predicts subsequent development in mathematics more accurately than other abilities “such as visual attention, metacognitive knowledge, and listening comprehension” (p. 478).

The consensus in the mathematics education community is that too few early elementary students in the United States have developed the rich understanding of number that children require as they subsequently encounter more advanced topics in school. This desired “rich understanding” is commonly referred to in the literature as number sense. “Number sense refers to a person’s general understanding of number and operations along with the flexible ways to make mathematical judgments and to develop useful strategies for handling numbers and operations” (McIntosh, Reys, & Reys, 1992, p. 3).

While it is commonly agreed that young children’s development of flexible and connected concepts of number are a prerequisite for subsequent achievement, it is also recognized that it is difficult to provide students with opportunities to develop this multi-faceted number sense in the rigid structure of the traditional school day. Number sense requires multiple and varied experiences with numbers, and it is difficult to package such experiences in curricular materials designed for daily, 45-minute math sessions. Furthermore, there is a high level of variability of number concept readiness across individual students, suggesting that different students will require different learning experiences in order to develop this knowledge base. Verschaffel et al. (2007) state that “children’s early understanding of arithmetic should be viewed in terms of multiple, loosely connected weak schemes. As such, it seems inevitable that a neat linear description of developmental stages will always be complicated by the exigencies of individual differences in cognition and in experience” (p. 591).

As noted earlier, the Augustana/Longfellow partnership is providing opportunities to provide this kind of individualized instruction for the diverse group of Kindergarten students at Longfellow. The presence of thirty-two undergraduate students within the school has provided the “manpower” required to assess and develop the numerical understanding of each and every child. The challenge for us, then, has been to ensure that the learning activities we have devised for the children will truly meet the stated goal of promoting the development of number sense.

Development of Software and Other Materials

We have been collaborating with Longfellow’s kindergarten teachers on developing a set of age-appropriate mathematical activities since the spring of 2009. We have also worked with them and personnel from
the Rock Island school district in identifying appropriate assessment instruments for gauging the progress of the children. The activities we have designed include numerical games, manipulatives, and the software which is the focus of this paper. Many of these activities, especially the software, were field tested with children aged 4-6 years during the summer of 2009. Thus, we had the opportunity to refine our materials before formally implementing them at Longfellow in the fall.

We had two overriding goals in mind as we developed our materials generally and our software specifically. First, we wanted to ensure that our educational materials complemented Longfellow’s regular mathematics curriculum, Kendall/Hunt’s *Math Trailblazers*. Second, we wanted our materials to be developmentally appropriate and thus correspond to early childhood learning targets identified in the research literature. With these goals in mind, we believe that our materials are immediately relevant to this particular school, thus avoiding a common shortfall of mass-produced commercial software which may have some general value but cannot be tailored to specific need of particular contexts (Viadero, 2009). Additionally, we believe that the research foundation informing our work provides a firm rationale for our design choices.

The work of Fuson et al. (2001) and Van de Walle (2004) were particularly influential during our design process. These authors have developed frameworks describing the numerical concepts children should know at this age, what they can know, and what their general learning trajectory will be as they move toward what they will know. These concepts include the ability to recognize that appropriate counting requires a one-to-one correspondence between counting words and objects counted; the ability to relate words, numerals and physical referents; the ability to recognize the cardinality of a set; the development of a spatial recognition of numbers; the ability to partition numbers; and the ability to connect numbers to important benchmarks such as 5 and 10. The learning activities we developed are intended to provide opportunities for different students to work with concepts most appropriate for them.

As of this writing, six software applications are included with our overall set of materials. We intend to develop additional software in the upcoming months by seeking input from both the in-service kindergarten teachers and our pre-service student teachers regarding how software might further support their efforts in mathematics. Our current set of software applications address a range of early childhood numerical competencies identified in the assessment instruments drawn from Kathy Richardson’s *Assessing Math Concepts* series, published in 2003 by Math Perspectives, Bellingham, WA. In consultation with the teachers, we are considering supplementing our assessment data with assessment instruments drawn from Longfellow’s regular mathematics curriculum, *Math Trailblazers*, published in 2008 by Kendall/Hunt Publishing Company, Dubuque, IA.
literature. “Count Sort” is a basic activity designed to help students organize the counting of objects and hence develop the “one-to-one” competency. “Ah Chute” is a competitive game which provides further counting practice, begins to help students organize numbers into groups of 5, and helps students recognize the various combinations of numbers whose sum is 5. “Pattern Sets” prompts students to move beyond always counting objects to determine cardinality, and instead leads them to recognize various spatial representations of numbers and begin to think of numbers relationally (e.g., recognize that 7 can be thought of as “2 more than 5” or “3 less than 10,” etc.). “What’s Hiding” further reinforces the skill of thinking relationally about numbers and being able to partition them. With this application, students are shown a set of objects, and then some of the objects are hidden from view. Students must determine the hidden quantity, thus applying ideas such as “7 can be formed with a 5 and a 2,” etc. “Word Problems” randomly generates contextual situations which force students to translate verbal language into mathematical operations. Finally, “Math Balance,” a game for the most advanced students, develops a pre-algebraic conception of the “=” symbol as an indicator of equality, thus helping dispel the myth that it indicates that an operation must be performed.

**Students’ Reaction to the Software: Initial Observations**

The implementation of our number sense project at Longfellow is only a few weeks old, thus we have very little basis to judge how the software has been received or if it is having any impact on the students’ learning. We can make anecdotal observations about how children responded to the software during our summer field-testing and during initial software encounters at Longfellow this academic year. In brief, we are confident that our software provides the skill practice that we intended and that is accessible to 5-6 year-old children. In the summer months, we found that children “caught on” to how to operate the software quickly, and the children’s verbal comments as they played the games indicated that their mathematical thinking aligned to our expectations. During our initial experiences at Longfellow in the fall, the bulk of the work we have done with the kindergarteners has involved the use of manipulatives and other non-electronic games. However, in the few instances when our pre-service teachers have presented software to the children, the children have responded favorably to the software and were able to sustain their interaction with the software for several minutes (no small feat for this age group). While we sense that the software is worthwhile, we also firmly believe that it cannot stand alone as the only means of supporting the children’s development of number. Both during the summer field testing and during our initial encounters within the school, it has been clear that the children require a diverse set of learning experiences beyond the software.
These diverse experiences include opportunities to incorporate movement in their learning, opportunities to engage with physical manipulatives, and opportunities to play non-electronic educational games.

**Moving Forward**

Our number sense work at Longfellow has only begun to take hold, thus we are currently presenting this project as a work-in-progress. As we move through the current school year, we anticipate gathering further data which will enable us to make more definitive judgments about the value of our number sense interventions. We have been in communication with officials from the Rock Island school district who have expressed an interest in comparing end-of-year kindergarten assessment data between Longfellow and other schools in the district. This will give us one indication of how effective our efforts have been. As noted earlier, as the school year progresses and the number college students available to work with the children decreases, we anticipate that the teachers will utilize our software more often as “station time,” or small group-level work requiring less immediate teacher supervision. This increased use of the software should provide further insight into how useful the software itself is as a tool for helping children develop numerical concepts. Finally, we are considering the option of continuing to track this group of kindergarteners as they progress through school, thus giving us an indication of whether our materials have any impact on long-term development. We intend to share our new findings as they become available, and welcome inquiries about our project from other interested professionals as we continue to engage in this work.

**REFERENCES**


