

Multiage Mathematics: Scaffolding Young Children's Mathematical Learning

Exploration, inquiry, manipulation, discussion, and discovery all come to mind when we envision young children involved in mathematical activities. Early childhood education engages students in an exploratory journey from birth through age 9 in empirical mathematical concepts. The focus of early mathematics is to develop a strong foundation of the requisite skills and concepts throughout NCTM's five Content Standard strands (NCTM 2000). The wide ranges of abilities and understandings of mathematical concepts in early childhood classrooms challenge teachers to meet all students' intellectual needs. In this article, teachers of primary-grade multiage classrooms describe how they used scaffolding to capitalize on the wide ranges of abilities and met their students' needs by providing opportunities for their young learners to work together to understand mathematical concepts.

The Strategy of Scaffolding

The notion of scaffolding emerged from Vygotskian theory based on the important role that social interaction plays in learning. Vygotsky (1978) asserted that children should be involved with others in educational experiences that lie just beyond their actual developmental levels. He defined the area of learning just beyond the level of development as the zone of proximal development: "the distance between the actual development as determined by independent problem solving and level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky 1978, p. 86). Vygotsky also promoted the idea that effective instruction targets that zone lying just beyond the skills that the child has already mastered. Scaffolding can occur when children and teachers converse about tasks and activities and engage in joint

problem-solving situations. Children who vary in their cognitive and social abilities can provide scaffolding for one another when given opportunities to work together. Early childhood teachers can also provide scaffolding for their students. They manage to "mediate learning so that groups and individuals develop an understanding of both the concepts and the means of communication appropriate to the context" (Warwick and Maloch 2003, p. 54). In this way, teachers adept at mediating allow a concept to infiltrate a student's mind and become an imprint of a more complex concept to be recalled later, giving their students "resources for learning" (Halliday and Martin 1993, p. 22).

The teachers of multiage students who contributed to this article value the benefits of children with varying knowledge and experience working and learning from one another and promote a variety of scaffolding learning situations, such as peer-to-peer collaboration, teacher-led heterogeneous and homogeneous small-group learning, and whole-class problem-solving experiences. In our primary-grade multiage classrooms, we organized

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these situations purposefully to allow for the children to get the biggest gain from working together with their classmates and teachers.

Scaffolding Mathematical Concepts

Providing opportunities for varied, flexible groupings allows scaffolding to happen naturally as children learn mathematics. As teachers, we scaffold concepts (support the building of knowledge by connecting one concept to another) but also allow children to create their own scaffolding by interacting with peers while absorbing the concept. Scaffolding is temporary. Like the supports that construction workers use on buildings, scaffolding is a support put in place to aid in the completion of a task, then eventually removed when no longer needed. Humans are social beings; like adults, children learn best through social interaction. Planning for and supporting certain scenarios during mathematics instruction and exploration scaffolds learning for children who are on the verge of grasping a concept, as well as those who have learned a new concept and are ready to be further challenged. The social interaction provides the scaffolding for the challenges and higher-level thinking that children need to move naturally to the next, more complex concept.

To illustrate scaffolding in action, experienced teachers of multiage classrooms in the United States and Australia shared their observations of scaffolded learning situations in mathematics instruction. It is important to note that Vygotsky's "more capable other" is sometimes the teacher and sometimes a classmate.

Teacher as "the more capable"

Building relationships and making connections in mathematics allows students to scaffold and create schemas for later learning. To illustrate this process, envision a mixed-aged class of children ranging in age from 6 to 8. The children are around a table where the teacher has strategically placed manipulatives for sorting and classifying. The children are enthusiastic about the objects as they touch them and use them in various ways. After fifteen minutes of exploration, the enthusiasm is guided into concept formation by the teacher's conversation and prompting. The teacher begins to discuss how each manipulative can be sorted by its characteristics. She extends the information by showing how two like objects result in a certain number when

combined, introducing the concept of addition. For instance, if the children are using attribute blocks for sorting, the teacher may help them notice how some blocks are thinner than others and encourage them to sort accordingly. Then, as the children sort three thin yellow circles and two thicker yellow circles, the teacher points out that, although there is a difference in the thickness, there are five yellow circles altogether. As the teacher begins the conversation about addition, some students continue with their free exploration, while others attend to the teacher. Those who attend intellectually are *ready*, conceptually, for the guided lesson. Additional prompting by the teacher serves to guide other potential learners. As those who are attentive are asked to manipulate the objects purposefully for the sake of generating addition problems, the others watch the modeling, listening to the discussion. Thus scaffolding is provided that will be the support, or foundation, for later learning. When these students hear of the addition concept again, it will heighten their readiness to formally begin a guided inquiry.

Classmate as "the more capable"

The very philosophy of multiage teaching leads naturally to the development of communities of mathematics learners. It is natural for children to engage in situations from which they can generate new ideas and to be immersed in the language and concepts just within their zone of proximal development (Vygotsky 1978). The following scenario was recorded as a small group of 6-, 7-, and 8-year-olds worked together on a hands-on activity with multiple entry and exit points. One of the students had observed that when adding two even numbers, the result is an even number. The teacher challenged small groups of students to find out whether adding even numbers always results in an even number and then to find out what happens when two odd numbers or an odd and an even number are added.

Working in small mixed-age groups, the children were given a pair of dice and asked to record the results of adding two numbers. Two instructions were given: (1) Record the pairs of numbers and totals and label them (O) for odd and (E) for even as appropriate; and (2) share mental addition strategies for each addition problem. As the children set to work, discussion ensued about the best strategies for particular pairs of numbers. For $3 + 4$, for instance, we heard a younger child say,

“I used a *count on three* strategy and the answer was seven.”

An older child tried to explain that a near double was another option. We watched as the child drew the 3 and the 4 as shown on the dice and circled two sets of three, saying, “So we have double 3 is 6, plus 1 is seven.”

This exchange is a typical example of the classmate as “the most capable.” In this instance, it was an older child demonstrating capability, but in the following example it was a younger child demonstrating capability.

After recording several examples, some of the children began to realize that in order to interpret the data they were generating, they needed to be more systematic. A younger child in one group drew two lines down his paper to make three columns and said, “We need three spaces, O + O, E + E, or O + E, or the other way round is the same.”

An older child accepted the input and wrote the labels for the headings. As the children reflected on the activity, all of them were able to offer a pair of numbers, name the mental strategy they used to compute it, and begin to generalize from the class data. One of the younger children asked, “What if we used three dice next time?”

This activity was well suited for a multiage class, or any class with a range of abilities, for two reasons. First, the multiple entry points allowed every child to add the dots on the dice together by using a low-level count-all strategy or applying a more sophisticated mental strategy: “I saw the 5 and the 4 and knew that it was double 4 plus 1.” Second, multiple exit points were evident in terms of the strategies students used and the conclusions they made.

All the children were immersed in the strategies and the meta-language attached to them and generated addition pairs. In the future, some students may recall one of the strategies they thought worked well and will give themselves a push along to try it out. Some children actually drew pictures of dots joining pairs of dots to decide whether the numbers they represented were odd or even; at the same time, they themselves were laying the foundation for deep understanding of the concept of odd and even. Sharing the different strategies for organizing the data also allowed for immersion in different types of lists and tables and discussions about which showed the information most clearly. Remarkably, it was a younger child who sug-

gested using O and E as abstract terms without attaching numbers to them.

Concluding Thoughts

As we pointed out earlier, scaffolding occurs naturally in a multiage class of young learners. In multiage classes, no assumptions exist that children will be at similar stages of development. As teachers of single-grade classrooms also know, their students represent a wide range of development as well. Likewise, young children’s rates of development and knowledge about concepts in mathematics such as patterns in addition also vary. Providing opportunities for teacher and classmate scaffolding enables students to have success at their level and also to be challenged to reach their developmental potential.

References

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- National Council of Teachers of Mathematics (NCTM). *Principles and Standards for School Mathematics*. Reston, VA: NCTM, 2000.
- Vygotsky, L. S. *Mind in Society: The Development of Higher Psychological Processes*. Cambridge, MA: Harvard University Press, 1978.
- Warwick, P., and B. Maloch. “Scaffolding Speech and Writing in the Primary Classroom: A Consideration of Work with Literature and Science Pupil Groups in the USA and UK.” *Reading, Literacy, and Language* (July 2003): 54–63.

Additional Resources

Readers looking for additional resources that give insight into the mathematical thinking and reasoning of young children might also enjoy the following:

- Carpenter, Thomas P., et. al. *Children’s Mathematics: Cognitively Guided Instruction*. Reston, VA: National Council of Teachers of Mathematics, 1999.
- Copley, Juanita V. *Mathematics in the Early Years*. Reston, VA: National Council of Teachers of Mathematics, 1999.

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