

Introduction

Number &
Operations

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Communication Standard for Grades Pre-K-2

Instructional programs from prekindergarten through grade 12 should enable all students to—

- organize and consolidate their mathematical thinking through communication;
- communicate their mathematical thinking coherently and clearly to peers, teachers, and others;
- analyze and evaluate the mathematical thinking and strategies of others;
- use the language of mathematics to express mathematical ideas precisely.

Language, whether used to express ideas or to receive them, is a very powerful tool and should be used to foster the learning of mathematics. Communicating about mathematical ideas is a way for students to articulate, clarify, organize, and consolidate their thinking. Students, like adults, exchange thoughts and ideas in many ways—orally; with gestures; and with pictures, objects, and symbols. By listening carefully to others, students can become aware of alternative perspectives and strategies. By writing and talking with others, they learn to use more-precise mathematical language and, gradually, conventional symbols to express their mathematical ideas. Communication makes mathematical thinking observable and therefore facilitates further development of that thought. It encourages students to reflect on their own knowledge and their own ways of solving problems. Throughout the early years, students should have daily opportunities to talk and write about mathematics. They should become increasingly effective in communicating what they understand through their own notation and language as well as in conventional ways.

What should communication look like during prekindergarten through grade 2?

Children begin to communicate mathematically very early in their lives. They want *more* milk, a *different* toy, or *three* books. The communication abilities of most children have developed tremendously before they enter kindergarten. This growth is determined to a large extent by the children's maturity, how

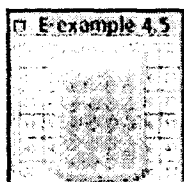
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language is modeled for them, and their opportunities and experiences. Verbal interaction with families and caregivers is a primary means for promoting the development of early mathematical vocabulary.

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Language is as important to learning mathematics as it is to learning to read. As students enter school, their opportunities to communicate are expanded by new learning resources, enriched uses of language, and experiences with classmates and teachers. Students' developing communication skills can be used to organize and consolidate their mathematical thinking. Teachers should help students learn how to talk about mathematics, to explain their answers, and to describe their strategies. Teachers can encourage students to reflect on class conversations and to "talk about talking about mathematics" (Cobb, Wood, and Yackel 1994). »

An important step in communicating mathematical thinking to others is organizing and clarifying one's ideas. When students struggle to communicate ideas clearly, they develop a better understanding of their own thinking. Working in pairs or small groups enables students to hear different ways of thinking and refine the ways in which they explain their own ideas. Having students share the results of their small-group findings gives teachers opportunities to ask questions for clarification and to model mathematical language. Students in prekindergarten through grade 2 should be encouraged to listen attentively to each other, to question others' strategies and results, and to ask for clarification so that their mathematical learning advances.



Calculators and
Hundred Boards
(Part 1)

Adequate time and interesting mathematical problems and materials, including calculators and computer applications, encourage conversation and learning among young students, as demonstrated in the following episode, drawn from a classroom experience:

Rosalinda, usually a quiet child, was very excited to learn how to skip-count to 100 on the calculator. However, she was puzzled when counting to 100 by threes. "It always goes over 100!" she exclaimed. The teacher encouraged Rosalinda and her partner to investigate the phenomenon. Over several days, the students talked together about why the calculator did not display 100 when they counted by threes. They used the hundred board and counters along with their calculator and concluded that equal groups of twos could be made with 100 counters but not equal groups of threes. The investigation resulted in a chart that Rosalinda and her partner made to explain to the class what they had figured out and how the calculator had supported their

conclusions.

Experiences such as this help students see themselves as problem posers and also see how tools such as calculators can be used to support their mathematical investigations.

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Manipulating objects and drawing pictures are natural ways that students communicate in prekindergarten through grade 2, but they also learn to explain their answers in writing, to use diagrams and charts, » and to express ideas with mathematical symbols. Their language should become more precise as they use words such as *angles* and *faces* instead of *corners* and *sides*. Opportunities to express their ideas encourage students to organize and consolidate their mathematical thinking.

Young students' abilities to talk and listen are usually more advanced than their abilities to read and write, especially in the early years of this grade band. Therefore, teachers must be diligent in providing experiences that allow varied forms of communication as a natural component of mathematics class, as the following episode, adapted from Andrews (1996, p. 293), demonstrates:

A kindergarten teacher read a story about a family's journey across the country. She asked the students to make maps to show the route taken by the family. As they worked in groups, some students incorporated letters or other symbols into the work. One group drew pictures of each landmark. Another group asked the teacher to help them label parts of their map and numbered each step along the way. As each group shared its work with the class, the teacher asked what changes they would make next time that might improve their work. The maps were hung in the hall, giving the teacher opportunities to question the students about the mathematical ideas of space and navigation they had used in creating the maps.

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What should be the teacher's role in developing communication in prekindergarten through grade 2?

Teachers can create and structure mathematically rich environments for students in a number of ways. They should present problems that challenge students mathematically, but they should also let students know they believe that the students can solve them. They should expect students to explain their thinking and should give students many opportunities to talk with, and listen to, their peers. Teachers

should recognize that learning to analyze and reflect on what is said by others is essential in developing an understanding of both content and process. When it is difficult for young learners to follow the reasoning of a classmate, teachers can help by guiding students to rephrase their reasoning in words that are easier for themselves and others to understand. Teachers should model appropriate conventional vocabulary and help students build such vocabulary on the basis of shared knowledge and processes.

Teachers should support students' mathematics learning through the languages that they bring to school; they should also help them develop standard English vocabulary and mathematical terms that will enable them to communicate better with others. Students should be encouraged and respected when they use their native language as well as English in their mathematical communications. If possible, the mathematical terms should be displayed in both English and the native languages. Students who are not yet proficient in English can be paired with other students who speak the same language and with bilingual students or community volunteers, who can support the communication of ideas to the teacher and the rest of the class.

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Teachers also need to be aware that the patterns of communication between students and adults in the school may not necessarily match the patterns of communication in students' homes. For example, patterns of » questioning can be very different. In some cultures, adults generally do not ask questions when the answer is known; they ask questions primarily to seek information that they do not have. In school, however, teachers frequently ask questions to which the answer is known. Students who are not accustomed to such questions can be bewildered, since it is obvious that the teacher already knows the answers. Similarly, in some cultures, people routinely interrupt one another in conversations, whereas in others, interruptions are considered extremely rude. Students from the first group may unduly dominate class discussions. In other cultures, children are expected not to ask questions but to learn by observation. A student from such a group may be uncomfortable asking questions in class (Bransford, Brown, and Cocking 1999). Teachers need to be aware of the cultural patterns in their students' communities in order to provide equitable opportunities for them to communicate about mathematical thinking.

Building a community of learners, where students exchange mathematical ideas not only with the teacher but also with one

another, should be a goal in every classroom. Consider the following example, which has been drawn from a classroom experience:

A teacher asked, "How many books do I need to return to the library if I have three nonfiction and four fiction books?" A student who seldom shared his answers with the class voluntarily responded, "Seven." In the past, if the teacher asked him how he figured out a problem, the student just shrugged his shoulders. This time, however, the teacher decided to involve another student and asked her, "How do you think Maury figured it out?" The second student held up three fingers as she answered, "I think he did it this way. I know there are three, so I just put up four more fingers and then count them all." This prompted Maury to respond, "I did it a different way. I just knew that three and three make six and then I counted one more."

The teacher thus set the stage for two students to explain their methods and for all their classmates to hear and discuss the two ways of thinking about the same problem.

Just as teachers accept multiple forms of communication from their students, so they should also communicate with the students in a variety of ways to ensure maximum success for all. For example, because not all children at this level are able to follow written instructions, teachers could decide to read instructions or to draw pictures to represent the sequence and contents of a task.

It is the responsibility of the teacher to recognize appropriate times to make connections between invented symbols and standard notation. When students present their own representations of their mathematical knowledge, the presentations are often unique and creative. For instance, figure 4.30 is a kindergartner's notation to remember that a jar held ten and a half scoops. Teachers must seek to understand what students are trying to communicate and use that information to advance individual students' learning and that of the class as a whole. The use of mathematical symbols should follow, not precede, other ways of communicating mathematical ideas. In this way, teachers help young students relate their everyday language to mathematical language and symbols in a meaningful way.

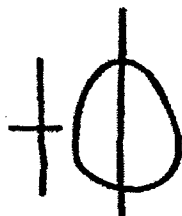


Fig. 4.30. A child's notation for 10 1/2

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