When we talk about our prekindergarten curriculum development project, we sometimes hear statements such as the following:

“I think it’s a shame that we have turned our backs on the long tradition of early childhood education and have to teach mathematics.”

“It’s great that someone is finally introducing mathematics to this age child.”

It would seem natural to hope that the audience agrees more with the second person than the first. However, both statements make the common but incorrect assumption that engaging young children in mathematics is a new development.

Before we decide whether early childhood mathematics is “shameful” or “great,” we should look at its history.

Mathematics in Early Childhood through the Years

Frederick Froebel (1782–1852), the inventor of kindergarten, was a crystallographer. Almost every aspect of his kindergarten incorporated his interest in the “universal, perfect, alternative language of geometric form” (Brosterman 1997, p. 12). Its ultimate aim was to instill in children an understanding of what an earlier generation would have called “the music of the spheres”—the mathematically generated logic underlying the ebb and flow of creation. Froebel used “gifts” to teach children the geometric language of the universe. Cylinders, spheres, cubes, and other materials were arranged and moved to show geometric relationships. Structured activities followed that included exercises in basic arithmetic, geometry, and beginning reading skills. For example, the cubes that children used to form chairs and stoves would be rearranged to make a geometric design on the grid etched into every kindergarten table (see fig. 1). Later, the cubes were laid into two rows of four each and expressed as “4 + 4.” Connections were important to the students’ understanding: the “chair” became an aesthetic geometric design, which became a number sentence.

Triangles, well known to children as parts of faces or other pictures (see fig. 2), were used to teach concepts in plane geometry (see fig. 3). Children covered the faces of cubes with square tiles and peeled them away to show parts, properties, and congruence. Many blocks and tiles composed carefully planned shapes that fit in the grids in different ways. “All the blocks and sticks and rings and slats were used in plain view on the ever-present grid of the kindergarten table, arranged and rearranged into shifting, kaleidoscopic patterns or decorative, geometric borders” (Brosterman 1997, p. 38).

Using these materials, Froebel helped his students to develop skills that had been—and still are—reserved for students in higher grades. Many of the
Cubes helped students in Froebel’s kindergarten make connections. Froebel used triangles in his lessons because of their familiarity to children.

Children in Froebel’s schools ranged in age from 3 to 7; so he can be said to have invented kindergarten and preschool as well.

It has been claimed that the experiences of R. Buckminster Fuller, Frank Lloyd Wright, and Paul Klee in Froebelian kindergartens are the foundation of all their creative work (Brosterman 1997). This supports the contention that mathematics in the early years is not a recent invention. To explore this position, consider another example, the traditional material of kindergarten building blocks. Children create forms and structures that are based on mathematical relationships. For example, children may struggle with length relationships in finding a roof for a building. They must understand length and equivalence to substitute two shorter blocks for one long block. Children also must consider height, area, and volume when working with building blocks. The inventor of modern unit blocks, Caroline Pratt, tells of children making enough room for a toy horse to fit inside a stable (Pratt 1948). In Pratt’s example, the teacher told preschooler Diana that she could have the horse when she had made a stable for it. Diana made a large stable with a low roof. After several unsuccessful attempts to fit the horse in the stable, she removed the roof, added blocks to the walls to make the roof higher, and replaced the roof. She then tried to put into words what she had done: “Roof too small,” she said. After the teacher gave her new words to use—high and low—Diana was able to clarify her explanation for the other children. Simply building with blocks can help children to form important ideas. These intuitive ideas can be fostered by teachers such as Diana’s, who discuss the ideas with the children and give words to their actions. For example, teachers can help children to distinguish between different quantities such as height, area, and volume. In one instance, three preschoolers made towers and argued about whose was the biggest. Gesturing to reinforce her words, their teacher asked them if they meant to ask whose was tallest or widest or used the most blocks. The children were surprised to find that the tallest tower did not have the most blocks.

Unfortunately, typical kindergarten building blocks have features of the less structured toy design against which Froebel reacted. They do not have the same mathematics modularity as the blocks that Froebel used. Nevertheless, both types of blocks were designed with mathematics in mind.

So why is it the popular conception that traditional early childhood education does not include mathematics? Reluctance to teach mathematics to young children also has a long history (Balfanz 1999). Advocates of early childhood mathematics consistently have been met with objections from those who claim it is inappropriate for young children. Even Froebel’s ideas became diluted and polluted over time, and child advocates protested the results based on theory rather than on direct observations of young children. The objections arose from broad social trends. Educators who spend considerable time with children observe them joyfully engaging in sophisticated mathematical activities (Balfanz 1999; see also Ginsburg and Seo, in press). From
Early Research: Comparing Approaches

If we do wish to teach mathematics to young children, how should we do it? A study conducted by one of the authors (Clements 1984) compared two approaches. One approach took the then-popular, and still influential, position that early instruction on number skills is useless (see also Baroody and Alexis 2001). Based on an interpretation of Piaget's work, this position held that if a child does not conserve number—that is, believes that changing the arrangement of a collection changes its numbers—then instruction on number skills may even be harmful. If mathematics is taught at all, advocates of this position claimed, it should focus on the logical foundations of classifying, ordering, and conserving.

The other approach claimed that children build competency with number directly. According to this approach, number skills, such as counting, are complex cognitive processes that play a critical and constructive role in development of number and logical foundations in young children (Clements and Callahan 1983).

Four-year-olds in the study were randomly assigned to one of three groups: a logical-foundation group, a number group, or a control group. Members of the group that was taught classifying and ordering made significant gains in their understanding of those logical operations. The control group did not improve on any skills or abilities. It can be concluded that children benefit by engaging in meaningful number activities, many of which involve classifying and ordering.

Activities from this curriculum are available (Clements and Callahan 1983); this article describes only one. This activity and others have been updated and incorporated into our Building Blocks project. Use an adult-like, somewhat goofy-looking puppet and call it “Mr. Mixup.” Tell the children that Mr. Mixup frequently makes mistakes, and ask them to help Mr. Mixup count. They will listen to Mr. Mixup, catch his mistake, correct him, and then count with him to help him “get it right.” Have Mr. Mixup make mistakes such as the following, in approximately this developmental order:

**Verbal Counting Mistakes**

<table>
<thead>
<tr>
<th>Mistake</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wrong order</td>
<td>1, 2, 3, 5, 4, 6</td>
</tr>
<tr>
<td>Skipping numbers</td>
<td>...12, 14, 16, 17</td>
</tr>
<tr>
<td>Repeating numbers</td>
<td>...4, 5, 6, 7, 7, 8</td>
</tr>
</tbody>
</table>

**Object Counting Mistakes**

Figure 3: Triangles helped the students learn concepts in plane geometry.
Early Research:

<table>
<thead>
<tr>
<th>Mistake</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-to-one correspondence</td>
<td>• Skipping objects</td>
</tr>
<tr>
<td></td>
<td>• Count-point: saying one number but pointing twice (two different objects), or vice versa</td>
</tr>
<tr>
<td></td>
<td>• Point-object: pointing once but indicating more than one object, or pointing more than once to one object</td>
</tr>
<tr>
<td>Last-number</td>
<td>• Saying the wrong number as the &quot;final count&quot;; for example, counting three objects but saying, “1, 2, 3, there’s 4 there!”</td>
</tr>
<tr>
<td>Keeping-track-of-what’s-been-counted</td>
<td>• Double-counting: “coming back” and counting an item again</td>
</tr>
<tr>
<td></td>
<td>• Skipping objects when counting objects not in a line</td>
</tr>
</tbody>
</table>

Achieving Equity

Two other curricula stemmed from early research on equity issues. Sharon Griffin and the late Robbie Case (1995) found that children from low-income homes often lacked certain important quantitative concepts. For example, they could not count reliably beyond very small set sizes, and even when they could count, they often could not accurately compare numerical magnitudes. Therefore, they could not answer questions such as “Which is bigger, 6 or 5?” More important, the researchers discovered that they could remediate this knowledge gap in about twenty 10-minute instructional sessions, most of which were conducted in a game format. Indeed, after these experiences children from low-income homes scored the same as children from higher-income homes. Griffin and Case created a curriculum out of their research, which Sharon Griffin will describe in a future “Early Childhood Corner.”

Klein and Starkey developed and implemented a prekindergarten mathematics curriculum after their early research showed a similar, dramatic gap in mathematics understandings between different cultural and socio-economic groups (Klein and Starkey, in press). Children who worked in their curriculum significantly outperformed comparison children on number, geometry, and patterning skills. Klein and Starkey also will share ideas about their curriculum and research in a future “Early Childhood Corner.”

In 1998, the National Science Foundation funded several early childhood curriculum projects. The developers of these projects will describe their work in future editions of “Early Childhood Corner”: Herb Ginsburg, Carole Greenes, and Bob Balfanz; Beth Casey; and Julie Sarama and Doug Clements.

References


This paper was supported in part by the National Science Foundation under Grants No. ESI-9730804, “Building Blocks—Foundations for Mathematical Thinking, Pre-Kindergarten to Grade 2: Research-Based Materials Development”; REC-9903409, “Technology-Enhanced Learning of Geometry in Elementary Schools”; and ESI-98-17540, “Conference on Standards for Preschool and Kindergarten Mathematics Education,” as well as a grant for the conference from the ExxonMobil Foundation. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation or ExxonMobil Foundation.