Teaching Math to Young Children Practice Guide

Educators' Practice Guide Summary • WHAT WORKS CLEARINGHOUSE™

The five recommendations in this WWC practice guide, *Teaching Math to Young Children*, build on children's natural interest in math to make preschool and kindergarten more engaging and beneficial.

Introduction

Children are interested in math well before they start school. They notice basic shapes, construct and extend simple patterns, and learn to count. The *Teaching Math to Young Children* practice guide presents five recommendations designed to help early education teachers capitalize on children's natural interest in math. The first two recommendations identify early math content areas that should be included in the preschool, prekindergarten, and kindergarten curricula. The last three recommendations focus on strategies and teaching techniques that incorporate math content into the classroom.

This summary introduces the recommendations and supporting evidence described in the WWC's *Teaching Math to Young Children* practice guide. Download your free copy of the guide at http://ies.ed.gov/ncee/wwc/PracticeGuide.aspx?sid=18.

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Recommendation 1.
Teach number and operations using a developmental progression.

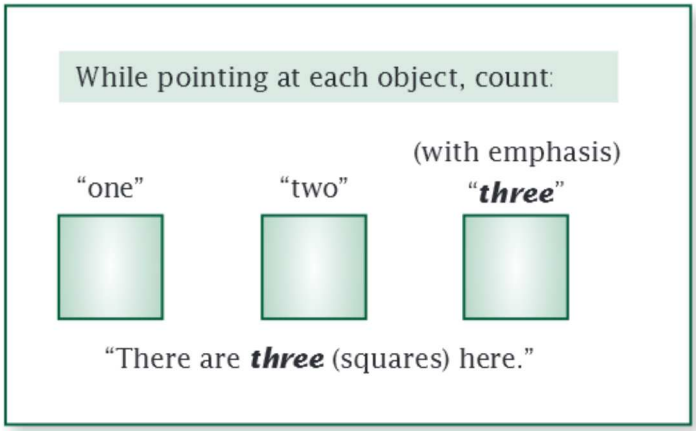
Early experience with number and operations is fundamental for acquiring more complex math concepts and skills. The practice guide describes how to teach the main aspects of early number knowledge, from basic number skills to operations, according to a developmental progression. Developmental progressions can provide teachers with a road map for delivering developmentally appropriate instruction to students of varying skill levels. With each step in a developmental progression, teachers can first focus on working with small collections of objects (one to three items) and then move to progressively larger collections of objects.

How to carry out the recommendation

1. **First, provide opportunities for children to practice recognizing the total number of objects in small collections (one to three items) and labeling them with a number word without needing to count them.** Teachers can give children experience with immediately recognizing and labeling quantities of a collection by having them answer the question "How many are there?" when looking at collections of one to three objects. Small-group activities, snack time, and transitions between classroom activities can provide quick opportunities for children to practice recognizing small quantities. To help children construct a more abstract concept of number, teachers can emphasize that collections of three similar objects and three dissimilar objects are both "three."

2. **Next, promote accurate one-to-one counting as a means of identifying the total number of items in a collection.** Once children have started to connect numbers with quantity, they can then begin to use one-to-one counting to identify "how many" are in larger collections. In order to count accurately, one—and only one—number word should be assigned to each item in the collection being counted, using the last number counted to determine the total quantity. The practice guide also includes a discussion of the common counting errors children make when developing counting skills and provides suggestions teachers can use to correct those errors when working with children in one-on-one or small-group situations (see page 19 of the practice guide).

Modeling one-to-one counting with one to three items



3. **Once children can recognize or count collections, provide opportunities for children to use number words and counting to compare quantities.** To begin magnitude comparisons, teachers can ask children to compare small collections of one to three objects visually. Next, children can count or match larger collections of items one-to-one to determine which set has "more." Once children can comfortably determine "more," the word "fewer" and the use of written number lists can be introduced. Eventually, teachers can encourage children to use their knowledge of which number comes after another in the counting sequence to determine the larger of two verbal numbers.

4. **Encourage children to label collections with number words and numerals.** After children practice recognizing, counting, and comparing quantities, teachers can introduce numerals to children as a way to represent a quantity. As described in the practice guide, teachers can pair numerals with collections of classroom objects so that children start to learn, for example, that the numeral 3, three objects, and the spoken word "three" represent the same thing (see page 21 of the practice guide).

5. **Once children develop these fundamental number skills, encourage them to solve basic problems.** Once children can determine the total number of items in a collection by using small-number recognition or counting and understand the concepts of "more" and "fewer," they can explore the effects of adding and subtracting items from a collection. As children become more adept, teachers can progress to more difficult problems with slightly larger numbers.

Summary of evidence

The WWC identified 23 studies that examined the effects of interventions that included targeted instruction in number and operations. The research shows a strong pattern of positive effects on children's early math skills across a range of curricula with a focus on number and operations. Eleven studies demonstrated positive effects for interventions that used a developmental progression to guide instruction in number and operations. While the panel could not confirm whether a developmental progression guided instruction in 12 other studies that taught number and operation, the panel felt that the body of evidence as a whole provided sufficient support to warrant a level of evidence rating of **moderate**. For more details, see Recommendation 1 in the practice guide, page 12.

Recommendation 2.
Teach geometry, patterns, measurement, and data analysis using a developmental progression.

The practice guide suggests that children's exposure to math should extend beyond number and operations to include a range of math content areas, including geometry (shapes and space), patterns, measurement, and data analysis. These math content areas should be taught according to developmental progressions. Learning skills beyond number and operations creates a foundation for future math instruction, and children with strong backgrounds in these areas are more likely to be able to succeed in later grades.

How to carry out the recommendation

1. **Help children to recognize, name, and compare shapes, and then teach them to combine and separate shapes.** Using their surrounding environment, teachers can provide opportunities for children to make comparisons and distinctions about the basic features of shapes. Once children are comfortable recognizing and comparing shapes, teachers should encourage children to explore how shapes can be combined and separated to form new shapes. Page 29 of the practice guide suggests activities to help children to learn about spatial relationships between shapes and master the concepts of "in," "on," "under," "beside," "above," or "below."

2. **Encourage children to look for and identify patterns, then teach them to extend, correct, and create patterns.** Pattern instruction can begin by encouraging children to notice and experiment with basic repeating patterns in the world around them, such as stripes on clothing and shapes and designs in rugs. Once children have become familiar with the nature of patterns, they should learn to predict what will happen next in a pattern, based on what has happened so far. Teachers will find ideas in the practice guide for using manipulatives, like the one shown in the example on the next page, to teach children about patterns of increasing complexity (see page 30 of the practice guide).

3. **Promote children's understanding of measurement by teaching them to make direct comparisons and to use both informal or nonstandard (e.g., the child's hand or foot) and formal or standard (e.g., a ruler) units and tools.** Teachers can help children learn to use measurement vocabulary words (long and short, big and small) to describe similarities and differences while sorting, arranging, and classifying objects. Once children have become comfortable making direct comparisons between and among objects, teachers can provide opportunities to measure objects using nonstandard tools, such as children's own hands and feet, pencils, blocks, or books. Children can then be introduced to the concept of standard units and tools of measurement.

4. **Help children collect and organize information, then teach them to represent that information graphically.** Teachers can introduce children to the concept of organizing and displaying information by asking them to count and sort familiar items like toys and blocks. This will help them learn both the characteristics that distinguish the items from one another and the total number in each set relative to other sets. Once children are familiar with sorting and organizing the information they have collected, they can learn to summarize their information visually through simple graphs and tallies.

Summary of evidence

The WWC identified 13 studies that examined the effects of interventions that provided targeted instruction in one or more of the early math content areas (geometry, patterns, measurement, and data analysis). Positive effects were found for geometry, operations, basic number concepts, and general numeracy outcomes. Studies also reported no discernible effects for general numeracy, geometry, and basic number concept outcomes. Although the evidence to support this recommendation is promising, the WWC could not isolate the effects of teaching the early math content areas of geometry, patterns, measurement, and data analysis. As a result, the WWC assigned a level of evidence rating of **minimal**. For more details, see Recommendation 2 in the practice guide, page 25.

Complex pattern (boy, boy, girl, girl, boy, boy, girl, girl, boy, boy, girl, girl)

Recommendation 3.
Use progress monitoring to ensure that math instruction builds on what each child knows.

Progress monitoring can be a useful way to ensure that children are participating in targeted, purposeful, and meaningful math instruction. By continually monitoring children's progress, teachers can gather the information they need to match lessons to children's knowledge levels. Incorporating children's individual differences into lesson planning by monitoring progress and tailoring instruction can help ensure that children learn fundamental concepts that are appropriately challenging and that will extend their learning.

Progress monitoring is a systematic approach to assessment with the goal of improving skills.

How to carry out the recommendation

1. **Use introductory activities, observations, and assessments to determine each child's existing math knowledge, or the level of understanding or skill he or she has reached on a developmental progression.** When employing progress monitoring, teachers can first gather specific information about each child's skill level in order to determine where to focus instruction. The practice guide suggests using introductory activities, observation, and formal assessments to determine each child's level of math understanding.

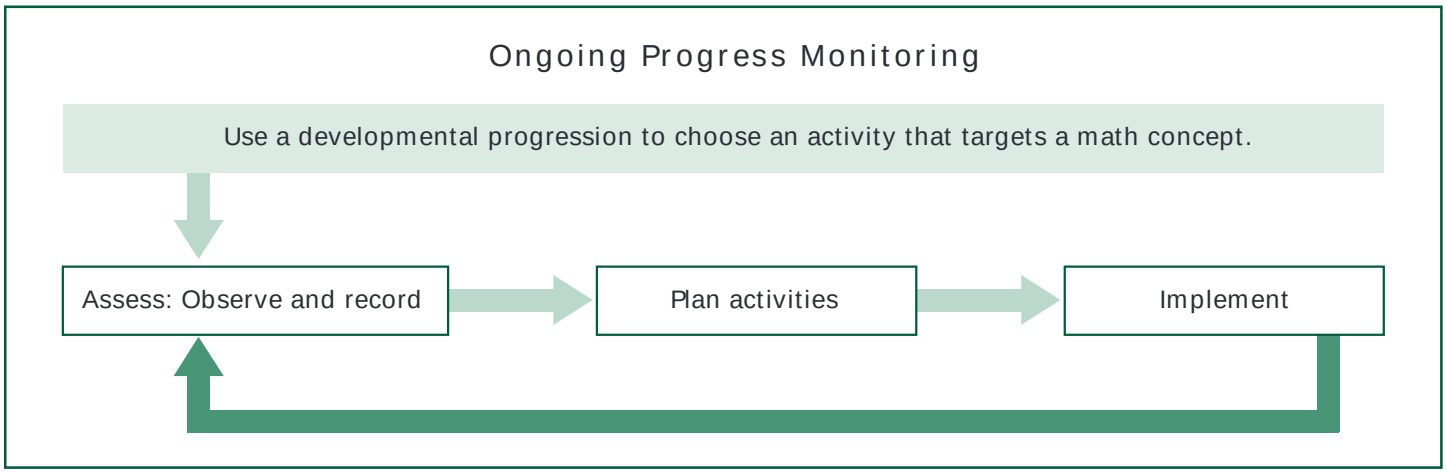
2. **Tailor instruction to each child's needs, and relate new ideas to his or her existing knowledge.** Once teachers have information about a child's skill level, they can use a developmental progression to determine what the child should learn next and design instructional activities with those needs in mind. Teachers can design small-group activities that are at or slightly above the children's level of understanding. As detailed in the practice guide, teachers can link math activities to children's existing interests and across other content areas to build knowledge, including music, art, games, and reading.

3. **Assess, record, and monitor each child's progress so that instructional goals and methods can be adjusted as needed.** The chart below illustrates the flow of progress monitoring. The practice guide describes how teachers can apply this ongoing process during math instruction (see page 39 of the practice guide). It is important to continually monitor progress so that children can be consistently engaged in activities that are neither too far below their level (and therefore not interesting) nor too far above it (and therefore frustrating).

Summary of evidence

The WWC identified 12 studies which examined the effects of progress monitoring on children's math knowledge when used in conjunction with other practices the WWC recommends for teaching math to young children. For example, four studies examining a comprehensive early math curriculum that included supports for regular assessments found that, on average, children participating in the intervention scored higher on math outcomes than did children in the comparison condition. Although the evidence to support this recommendation is promising, the WWC could not isolate the effects of the use of progress monitoring, since other recommended practices were also implemented. As a result, the WWC assigned a level of evidence rating of **minimal**. For more details, see Recommendation 3 in the practice guide, page 36.

Ongoing Progress Monitoring



Recommendation 4.
Teach children to view and describe their world mathematically.

The practice guide outlines the steps teachers can take to help children view and describe the world mathematically. Teachers can encourage children to describe math ideas in the world around them, gradually moving from informal representations and language to formal representations and math vocabulary as their understanding grows. At first, children can use informal tools such as their fingers, tally marks, or other concrete objects to represent math ideas. Once children are comfortable using math informally, teachers can help them link their informal knowledge to formal math vocabulary and representations, such as math symbols. Open-ended questions can be used to prompt children to think about how to describe their ideas mathematically. Teachers can reinforce these ideas by encouraging children to look for opportunities to use their developing math skills throughout the school day.

How to carry out the recommendation

1. **Encourage children to use informal methods to represent math concepts, processes, and solutions.** Initially, teachers should link math ideas to informal and familiar experiences, terms, or analogies, resisting the urge to use more formal methods until children have a conceptual foundation for understanding them. For example, teachers can first use terms such as "more" and "all together," terms that represent children's informal understanding of addition, before using the more formal, symbolic representation.

2. **Help children link formal math vocabulary, symbols, and procedures to their informal knowledge or experiences.** Once children develop an understanding of math ideas using informal terms, teachers can show them how their informal knowledge connects to formal math terms and representations. Teachers can start with informal vocabulary, like the phrase "take away," for example, and then later explain that the formal term "subtract" and the "–" symbol have the same meaning. The practice guide offers teachers ideas for using math vocabulary with children throughout the school day (see page 44 of the practice guide).

Lesson ideas for linking familiar concepts to formal symbols

Symbol	Concept	Lesson
numerals	counting	Have children count and record the number of children in attendance each day.
+ , –	operations	Have children solve problems involving adding or subtracting with leaves collected from the playground.
=	equal	Show the class four pennies. Next, show three pennies, verbally label them ("I have one, two, three pennies"), and put them in a can. Then, show one more penny, verbally label it ("I have one more penny"), and put it in the can. Ask the class, "Are three pennies and one more penny the same number as four pennies?"
< , >	unequal	Show the class five pennies, verbally label them, and put them in a can. Next, show four pennies, verbally label them, and put them in a different can. Ask the class, "Which can has more? Which can has fewer?"

3. **Use open-ended questions to prompt children to apply their math knowledge.** Open-ended questions not only help children to develop cognitive and language skills, but they also can encourage children to use math vocabulary to explain what they have learned. The practice guide provides teachers with ideas for promoting math-related conversation among young children using open-ended questions. For example, teachers can use questions that begin with "what," "why," or "how" to encourage children to use math vocabulary to explain what they have learned.

4. **Encourage children to recognize and talk about math in everyday situations.** Teachers can encourage math thought and conversation by asking children for their help with problems that arise throughout the day. Once children solve the problem, teachers can ask a sequence of questions that prompt the children to share the solution and the strategies used to reach the solution. Teachers will find several examples of ways to encourage math conversation and problem solving during recess, snack, transition, and small- and large-group time in the practice guide (see page 46).

Summary of evidence

The WWC identified 16 studies that examined the effects of interventions designed to help children view and describe their world mathematically. Some of the interventions provided math vocabulary words and suggestions for stories, songs, or questions that supported children in learning to view and describe their world mathematically. Studies examining these interventions found positive effects on children's math outcomes. Although the evidence to support this recommendation is promising, the WWC could not isolate the effects of helping children view and describe their world mathematically, since other recommended practices were also implemented. As a result, the WWC assigned a level of evidence rating of **minimal**. For more details, see Recommendation 4 in the practice guide, page 42.

Recommendation 5.
Dedicate time each day to teaching math, and integrate math instruction throughout the school day.

Devoting class time to planned, daily math lessons helps children strengthen math skills. By connecting math to a variety of everyday situations and routines, teachers can make math meaningful and provide opportunities for children to practice what they have learned in a purposeful manner. A math-rich environment can help generate excitement among children and encourage them apply their math knowledge in a meaningful way.

How to carry out the recommendation

1. **Plan daily instruction targeting specific math concepts and skills.** In order for young children to develop a strong foundation of math skills, teachers can dedicate time each day for purposeful math instruction. During math lessons, children can learn specific skills and build upon them throughout the rest of the day. The practice guide describes how large and small groups can be used during dedicated math time to tailor instruction for children at different developmental levels (see page 49 of the practice guide).

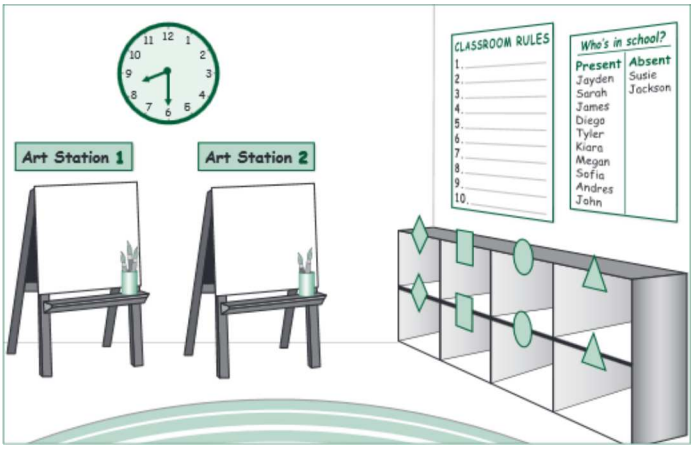
2. **Embed math in classroom routines and activities.** A daily or weekly schedule provides many opportunities to reinforce math concepts outside of the dedicated math instruction period. Routines such as taking attendance or

snack time can serve a math purpose in addition to a practical one, providing opportunities for counting, comparisons, and graphing.

3. **Highlight math within topics of study across the curriculum.** Teachers can integrate math concepts into non-math lessons by highlighting the aspects of math that are already present in the curriculum. This gives children opportunities to count and measure objects, examine shapes, and analyze data (depending on the current math objectives). The practice guide provides examples of ways to integrate different math content areas into literature, science, art, health and safety, and social studies lessons (see page 51 of the practice guide).

4. **Create a math-rich environment where children can recognize and meaningfully apply math.** Teachers can provide opportunities for children to see and use math concepts on a regular basis by creating a math-rich classroom environment. This enrichment can be done by making math-related objects and tools readily available, labeling and organizing them so they are easy to find and use, and organizing activities and routines with numeric systems. Teachers can also explicitly teach children how to use math tools by modeling their use during small- or large-group time.

An example of a math-rich environment in the classroom.



5. **Use games to teach math concepts and skills and to give children practice in applying them.** Games can provide an engaging opportunity for children to practice and extend skills, and the practice guide supplies several examples of games teachers can use to encourage children to apply their math knowledge. Teachers can use games that are included in math curricula, purchase games, make games themselves, or use games that come up during natural play, like hopscotch or jump rope, to reinforce math concepts. Teachers can get involved with the game-playing in order to ensure educational play or to challenge children to extend their skills.

Summary of evidence

The WWC identified 20 studies that examined the effects of interventions that included dedicated time for math instruction, integration of math into other aspects of the school day, and the use of games to practice math skills. A group of studies found that children who played number-based board games performed better in the domain of basic number concepts than did children who played color-based board games or no board games. Although the evidence to support this recommendation is promising, the WWC could not isolate the effects of the use of dedicated time for math instruction, integration of math into other aspects of the school day, and the use of games to practice math skills, since other recommended practices were also implemented. As a result, the WWC assigned a level of evidence rating of **minimal**. For more details, see Recommendation 5 in the practice guide, page 47.

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