



assessment report

# Early Mathematics and EMDA<sup>TM</sup>



Pearson Inc.

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## Introduction

With the advent of standards-based reform and the *No Child Left Behind Act* of 2001 (NCLB), educational systems are being held accountable to high levels of student achievement as never before. States are required to administer achievement tests in reading/English language arts and mathematics in grades 3 through 8 and in one high school grade. Because of the various implications of poor student performance on these assessments, which can include sanctions by federal and state administrators, educators have been re-examining instructional methods and practices. As a result of this re-evaluation, frequent monitoring of student progress and early intervention in student learning have become priorities for education.

The importance of assessing student achievement in various stages of learning has reaffirmed the utility of assessments as a way of guiding and informing instruction. The *Early Mathematics Diagnostic Assessment*<sup>™</sup> (EMDA), published by Pearson Inc. (2002a), is an example of an assessment designed for this role. EMDA is an individually administered instrument that evaluates the mathematics skills of young learners in grades PreK–3. Using results from EMDA, educators can identify areas of challenge for individual students and provide focused instruction. Through early intervention, students can build a solid foundation for future mathematics achievement. This report reviews current scientific research and expert opinion concerning the use of assessments to support early mathematics achievement and provides an overview of EMDA’s features and development.

## Background Education Research Supporting EMDA

The success of early intervention in raising the mathematics achievement of students is well established. Recently, the utility of *formative assessments* in guiding intervention has been the subject of education research and wide discussion by experts. Formative assessments are tests that are administered periodically before instruction to identify a student’s strengths and weaknesses in



a subject area (screening and diagnostic tests) or during instruction to monitor a student's progress in a subject area (progress monitoring tests). The educator can then plan instruction according to the student's needs as identified by the formative assessment results. By contrast, *summative assessments* are used to provide outcome measures, determining achievement after the completion of instruction (National Research Council, 2003). Over the past four decades, the formative and summative roles for assessment have been discussed and developed in education research (Black and Wiliam, 2003; Scriven, 1967; Stake, 1967).

While summative assessments (such as state accountability assessments) are more familiar to students and parents, the importance of formative assessment for improving education, particularly in mathematics, is being scientifically studied by education researchers and is widely cited by experts. Researchers have identified the use of formative assessments and early intervention as two important factors that can contribute to improving student achievement (Clarke and Shinn, 2004). Formative assessment and early intervention are most effective when used together before or during instruction. The information provided by a formative assessment can identify students who may require early intervention and enables the teacher to plan and choose instruction that directly meets a student's educational needs. The administration of additional formative assessments can be used to monitor the student's performance and growth throughout the intervention (Clarke and Shinn, 2004).

### **Building the Foundations of Mathematics Achievement**

Researchers have established that basic mathematical concepts acquired in early childhood are the foundation of later mathematics skills. Hence, difficulties encountered at early stages of mathematics learning may adversely affect a student's later academic success (Clarke and Shinn, 2004; Clements and Sarama, 2000). This finding is reflected in authoritative publications on mathematics instruction such as the *Principles and Standards for School Mathematics*, which asserts that "the foundation for children's mathematical development is established in the earliest years" and "many mathematics concepts, at least intuitive beginnings, develop before school" (National Council of Teachers of Mathematics [NCTM], 2000, p. 73).

While NCLB has many provisions for standardized assessment, the legislation only mandates the use of achievement tests beginning in grade three. Experts in mathematics education point out that if students are experiencing challenges by the time accountability testing begins, intervention is less effective than in earlier grades. Hence, there is wide agreement that formative assessments administered before grade three are useful for identifying a student's instructional needs. With this information, a teacher can provide needed intervention to a student while there is still time for instruction and remediation before accountability testing



(Clarke and Shinn, 2004; Clements and Sarama, 2000; Elmore and Rothman, 2000; Kilpatrick, Swafford, and Findell, 2001; National Research Council, 2005). Simultaneously with making this recommendation, researchers are careful to detail the appropriate ways to assess young children.

### **Appropriate Assessment for Young Children**

The types of assessments that are appropriate for young children are different from the standardized tests administered to children in later grades. Education researchers have scientifically established that group-administered paper and pencil tests may not be appropriate for educational assessment of young children at early developmental levels (Elmore and Rothman, 2000; McDonough, Clarke, and Clarke, 2002). Young children learn in an experiential and interactive way, such as by playing with objects (Bredenkamp and Rosegrant, 1992, 1995; NCTM, 2000). The abstract reasoning required to complete a paper and pencil test may prove frustrating for children who are at early developmental levels. Moreover, young children are not able to use writing tools as well as older children and typically lack the attention span necessary to take an assessment in a group setting. Therefore, the results from a group-administered paper and pencil test may not accurately reflect what the child knows and can do at early stages of learning (Elmore and Rothman, 2000). By contrast, older children (seven years old and above) are capable of using paper and pencil to respond to assessments. Hence, the approach used to assess the mathematics achievement of young children must be considered carefully.

### **One-On-One Assessment**

Today, the type of assessment that is recognized as most adaptable to the developmental level of young children is the one-on-one, or individually administered, assessment. This format can be designed to reflect more closely a child's natural learning environment and to use developmentally appropriate activities resembling those used in the classroom (Burns, Griffin, and Snow, 1999; McDonough et al., 2002). Perhaps most importantly, a one-on-one assessment facilitates behavioral observations, which can provide the teacher with an immediate insight into the capabilities and needs of the student (Burns et al., 1999; McDonough et al., 2002).

To provide reliable and valid data, a one-on-one assessment should be administered using high-quality methods that follow the *Standards for Educational and Psychological Testing* (AERA, APA, and NCME, 1999; Clarke and Shinn, 2004). The assessment should provide teachers with information that is relevant to the standards that will be used for accountability purposes in later grades. Hence, the assessment should measure the student's strengths and weaknesses regarding specific mathematics skills (Burns et al., 1999). If the

assessment is developed using a standardized process and is based on rigorous scientific research, it is possible to obtain norm-referenced scores from one-on-one assessments. This combination of behavioral observations, information about achievement of specific skills, and quantitative results makes the one-on-one format a remarkably effective and informative way of assessing young children.

## **The Early Mathematics Diagnostic Assessment (EMDA)**

To meet the need for a formative assessment of the mathematics achievement of young children, Pearson developed EMDA. A developmentally appropriate, norm-referenced instrument that can be used by classroom teachers, special educators, and diagnosticians, EMDA produces scientifically-based information about a student's mathematics progress. EMDA is designed to be used as a screening and/or diagnostic assessment so that the administrator can quickly obtain the information he or she needs to determine the next educational steps for the student. With this information, the teacher can then determine whether those steps require a different instructional approach or further assessment.

### **Features of EMDA**

Many of the features of EMDA correspond with the ideal qualities of assessments for young children discussed above. Aligned with the *Principles and Standards for School Mathematics* (NCTM, 2000), EMDA is comprised of items that address the mathematics skill domains identified as most important for young children. Hence, the information EMDA provides about a student's early mathematics skills and reasoning corresponds to the nationally recognized guidelines for mathematics instruction. EMDA is specifically designed to be administered in a way that is developmentally appropriate for children in grades PreK–3. To account for the short attention span of young children, the assessment can be administered in 15 to 20 minutes. The forms, prompts, directions for administering, and other test materials are teacher-friendly and easy to use. Other than the stimulus book, the record form, and the response book, the teacher who is administering EMDA only needs to provide eight pennies. Finally, the materials include everything needed to immediately score the forms and calculate the student's norm-referenced results.

### **Design of EMDA**

EMDA is based on the *Wechsler Individual Achievement Test*<sup>®</sup>—*Second Edition* (WIAT<sup>®</sup>–II) (Pearson Inc., 2002b), an individually administered assessment of achievement. WIAT–II was developed using a rigorous, scientific, national standardization study that included 5,586 individuals. Development of the mathematics portions of the assessment was guided by an advisory board of leading mathematics researchers. To build EMDA, items were selected from the



WIAT–II subtests for math reasoning and numerical operations. The content covered by the items ranges from skills and concepts associated with early math readiness, including identification of geometric states and counting, to more difficult skills, such as interpreting graphs and solving multi-step problems.

EMDA produces a norm-referenced score (percentile rank) that indicates a student’s achievement compared with the students in grades preK–3 who were a part of the WIAT–II reference group. In addition to producing a percentile rank, EMDA also groups student results into a category of achievement (emerging, below basic, basic, or proficient). These categories can be used to guide intervention or prevention planning, to assist in explaining a student’s performance to parents, and to give a concise recording of the student’s developmental progress at a given point in time.

Complementing the quantitative scores, qualitative analysis is another capability of EMDA. Observation of the steps in a student’s response to each item, such as using scratch paper or counting on fingers, enables the teacher to gain insight into the student’s progress and aids the teacher in planning instruction. A skills analysis corresponding to the two subtests provides the teacher with information about the student’s errors in regard to specific mathematical skills. The person administering the assessment is also encouraged to note any unusual or atypical behaviors that the student displays during testing. This information can be used to provide the teacher with a better understanding of the student’s areas of strength and weakness in specific mathematical skills, thereby highlighting the approach to intervention that the teacher should take, if necessary.

Table 1 provides a summary of the skills and concepts that are measured by the math reasoning and numerical operations subtests of EMDA.

**Table 1. Summary of the Concepts and Skills Measured by EMDA**

EMDA Subtest	Skills Measured	Grade Level
Math Reasoning	<ul style="list-style-type: none"> <li>• Counting</li> <li>• Ordering numbers</li> <li>• Identifying and comparing shapes, solids, lines, and angles</li> <li>• Creating and solving (addition, subtraction, multiplication, and division) problems using whole numbers</li> <li>• Using patterns to solve problems</li> <li>• Telling time and using time to compare and order events</li> <li>• Solving problems using or related to money</li> <li>• Using grids and graphs</li> <li>• Using non-standard units of measure</li> </ul>	PreK–3
Numerical Operations	<ul style="list-style-type: none"> <li>• Counting with one-to-one correspondence</li> <li>• Number identification</li> <li>• Number writing</li> <li>• Calculation (addition, subtraction, multiplication, division)</li> <li>• Fractions, decimals, percents</li> </ul>	K–3

### **Appropriate Uses for EMDA**

As with any assessment, the results that EMDA produces are only valid in the context of the test's design. Prior to testing, the person administering EMDA should determine whether the test is appropriate for the student. The assessment is not intended for students outside of the target age range of grades preK–3. Moreover, it may be inappropriate for students with severe disabilities, such as blindness, to be administered EMDA as they may not be able to respond to items in a way that will produce a valid score.

In summary, EMDA is intended as:

- a norm-referenced assessment of an individual student's achievement levels in mathematics
- an assessment of the student's achievement levels in mathematics
- a guide for the classroom teacher, providing critical decision-making information for instructional planning
- a means to link assessment results in mathematics to interventions

Once results from the assessment are obtained, anyone interpreting a student's scores should consider other factors such as the child's background and personality. The results of EMDA are not meant to be used as the sole factor in making a decision about the education of a child or to make any high-stakes educational decisions. EMDA should be placed in the larger context of other information, such as teacher observations, information provided by parents, and other assessment results. After intervention, additional administrations of EMDA can assist in determining whether a student has been receptive to instruction or requires further testing for potential disabilities. By providing empirically-based information, EMDA can effectively guide student instruction.

### **Conclusion**

In the current era of accountability in education, EMDA represents an important formative assessment instrument that educators can use to identify and meet the needs of their students. Given our knowledge about the benefits of early education, waiting until later grades to assess student mathematics achievement may be detrimental to all stakeholders—students, parents, and teachers. With EMDA, teachers and the education system as a whole can more effectively help students gain the knowledge and skills that they need for a successful future.

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