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The Early Grade Mathematics Assessment: Assessing children's acquisition of basic numeracy skills in developing countries

The Early Grade Mathematics Assessment (EGMA) is a one-on-one oral assessment designed to measure a student's foundation skills in numeracy and mathematics in the early grades. The instrument was first developed by the Research Triangle Institute (RTI) International through funding provided by the United States Agency for International Development (USAID) (RTI International, 2014c).

Origins and context

Basic mathematical skills during the early grades are important for future success in mathematics, which is instrumental for adults to function effectively in their work, profession, and everyday life. Also, countries need a skilled workforce to progress in science and technology, which are essential factors for economic growth (Global Partnership for Education, 2014; Hanushek & Wößmann, 2007; U.S.Department of Education, 2008).

However, the evidence resulting from large-scale international educational assessments, such as PISA and TIMSS, consistently indicate low learning levels in numeracy across many low-income countries (UNESCO Institute for Statistics, 2012). A substantial number of children in the developing world attend primary schools, yet fail to acquire a minimum level of numeracy skills. The real challenge lies where data from large cross-national studies do not offer information about what students of early grades in particular can do and cannot do, and what is causing the low level of performance in mathematics (UNESCO Institute for Statistics, 2012; Wagner, 2011).

Building on the experience of the Early Grade Reading Assessment (EGRA),[1] RTI designed the EGMA instrument to provide information about foundational mathematical skills which should be mastered in the early grades of 1–3. Development of the instrument was supported by USAID and carried out by RTI International in 2008. As of July 2015, 22 developing countries have administered or have plans of administering EGMA[2] (RTI International, 2014a). The original EGMA was revised in 2011 and renamed the Core EGMA. This pamphlet provides information about the Core EGMA hereafter.

Purpose

EGMA has been designed to use:

- as a country-level diagnostic tool to determine how students in a country are performing overall compared to its stated curriculum; and
- for program evaluation to examine the effectiveness of specific curricula, interventions, or teacher training programs (RTI International, 2014c).

On the other hand, it is suggested NOT to use EGMA:

- for cross-country comparison,
- for high-stakes testing,
- as input for student reports cards, and
- for program evaluation AND country-level diagnostics simultaneously (RTI International, 2014c).

1 For more details about EGRA, please refer to the Assessment GEM Series' pamphlet, which is available at http://www.acer.edu.au/files/AssessGEMs_EGRA.pdf.

2 The following countries have administered or have plans of administering EGMA: Afghanistan, the Democratic Republic of Congo, Dominican Republic, Ethiopia, Ghana, Iraq, Jordan, Kenya, Liberia, Malawi, Mali, Morocco, Mozambique, Nicaragua, Nigeria, Philippines, Rwanda, Sierra Leone, Somalia, Tanzania, Zambia and Zimbabwe.

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Measurement objective

Cognitive Domains

EGMA includes four cognitive subdomains to be assessed, accompanied by eight subtests. These subtests are Number Identification, Number Discrimination, Missing Number, Addition Level 1, Addition Level 2, Subtraction Level 1, Subtraction Level 2 and Word Problem (RTI International, 2014c).

The original purpose of developing EGMA was a need for a reliable measure of early grade mathematical skills that could be used across countries. Given this overarching purpose, the eight subtests were included based on the following criteria:

- They must represent a progress of foundational skills that support proficiency in mathematics.
- Research must indicate that the subtests have predictive power – that is, they must test skills related to students' future performance in mathematics.
- They must be common in many curricula for early grades.
- They must be teachable (RTI International, 2014c).

Table 1 describes the subtests of EGMA.

Other source of information

Some countries use EGMA in combination with other data collection tools such as EGRA and the Snapshot of School Management Effectives (SSME), both of which were developed by RTI International. Similar to EGMA, EGRA was designed to measure foundational skills for *literacy acquisition* in the early grades (Gove, Samir, Piper, & Ralaingita, 2013). SSME is an instrument that yields contextual information of school management and teaching practice (RTI International, 2010).

Combined implementations of EGMA, EGRA, and SSME is expected to provide rich data sets that enable policy makers, educators, and development partners to obtain a clear picture of students' foundational numeracy and reading skills. It may also be possible to gain better understanding of the management and teaching practices that influence student performance in a given region or country.

Target population and sampling methodology

EGMA targets students of grades 1 to 3. Similar to EGRA, EGMA is meant to be locally adapted to fit the needs of the local context (RTI International, 2014c). Therefore, sampling methodologies can vary from one application to another, depending on the assessment purpose, scope, and geographical circumstances.

For example, the Primary Math and Reading (PRIMR) Initiative in Kenya used a three-stage sampling process to obtain a random sample of its target population of Grades 1 and 2 students. It was carried out by randomly sampling: (1) geographical zones from the three participating regions; (2) schools within the selected zones; and (3) students within the selected schools (RTI International, 2012c).[3]

Another example is the Iraq Education Surveys project in which a three-stage stratified sampling process was employed to randomly sample its target population of Grades 2 and 3 students. The sample was drawn by selecting: (1) schools from all schools in the six participating provinces – those schools were stratified explicitly by province and, within each stratum, schools were stratified implicitly by district and combined enrolment size of Grades 2 and 3; (2) classes from each selected school; and then (3) students from each selected class (RTI International, 2012a).

Assessment administration

It is necessary to adapt EGMA tools before each administration to ensure that they reflect the needs of the local context. The adaptation process generally includes:

1. deciding the range of subtests to be piloted and implemented;
2. making sure that the items in EGMA are aligned with the country's curriculum for the grades being assessed; and
3. making sure the language used in the instruments is appropriate to the context (RTI International, 2014c).

In many large-scale assessments of mathematics, students are required to read in order to solve problems that are presented in a written format. Different to this, EGMA is administered orally by trained assessors.[4] Because EGMA is designed for the early grades, which is when children are just beginning to learn how to read, the oral administration is considered to be important to avoid confounding a child's ability to do mathematics with a child's ability to read or write (RTI International, 2014c).

The approximate administration length of EGMA is 20 minutes. This length of time generally prevents test fatigue, yet is considered to be long enough to allow for

3 For the PRIMR Initiative, EGMA and EGRA were used to examine the effectiveness of interventions that have been supported by USAID.

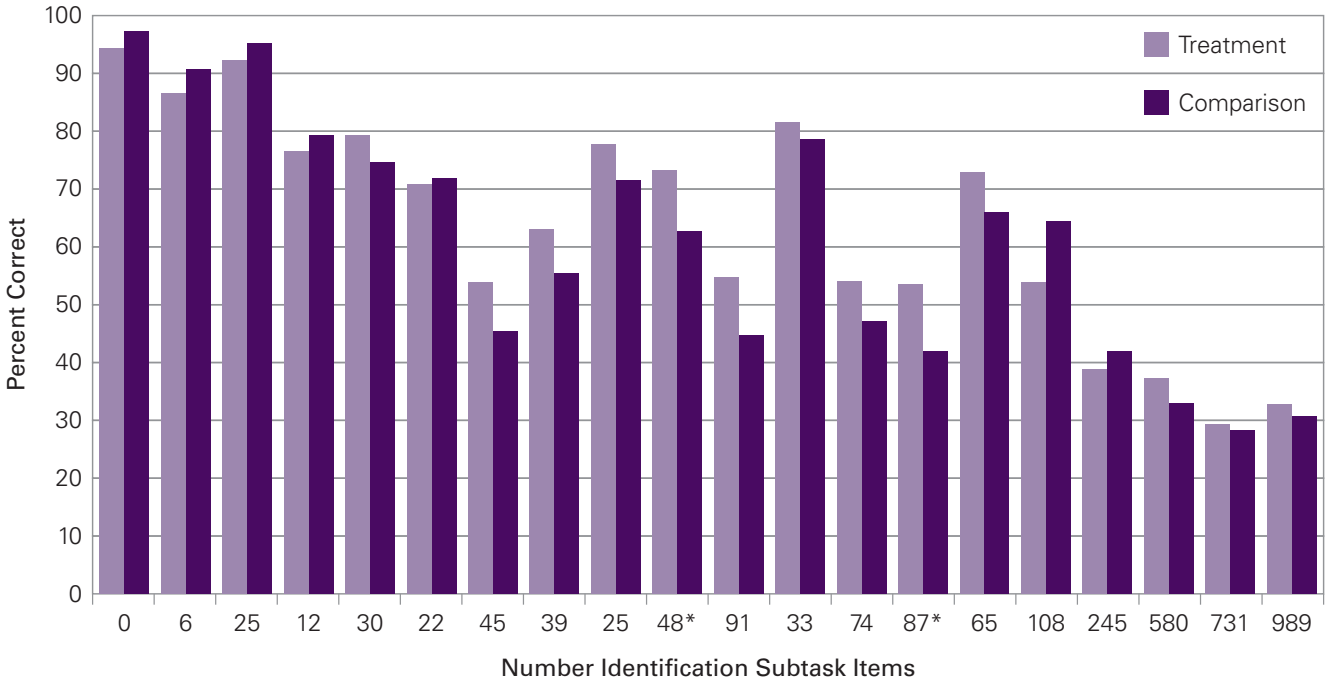
4 It can be administered by classroom teachers if EGMA is used for classroom assessment (RTI International, 2012e).

Table 1: EGMA Subdomains and Subtests

Subdomains	Subtests	Description
Number identification	Number identification	It consists of 20 items that increase in difficulty. It includes three single-digit numbers, 12 two-digit numbers and five three-digit numbers. Students are asked to say each number aloud (timed for 1 minute).
Number discrimination	Number discrimination	It consists of ten items. Each item consists of a set of two numbers, one of which is greater than the other. The subtest includes one set of one-digit numbers, five sets of two-digit numbers, and four sets of three-digit numbers. Students are asked to state the higher of each set of two numbers (not timed).
Number pattern identification	Missing number	It consists of ten items. The items are presented as four horizontally aligned boxes, three of which contain numbers and one of which is empty (the target missing number). Eight of the items increase in number from left to right; two of the items decrease in number from left to right. Items 1, 2, and 6 increase by one (in a set of one-, two-, and three-digit numbers, respectively). Items 3, 4, 5, and 8 increase by tens, hundreds, twos, and fives, respectively. Items 7 and 9 decrease by two and tens, respectively. The last item with numerals within the range of 1–20 increases by fives, but does not begin with a multiple of five. Students are asked to state the number that belongs in the empty box (not timed).
Addition and subtraction	Addition Level 1	It consists of 20 items that increase in difficulty. No addends are greater than 10, and no sums are greater than 19 (timed for 1 minute).
	Addition Level 2	It consists of five items that increase in difficulty. No sums are greater than 70. Addition Level 2 is not given to students who receive a score of zero for Addition Level 1 (not timed).
	Subtraction Level 1	It consists of 20 items that increase in difficulty. The Subtraction Level 1 problems are the inverse of the Addition Level 1 problems (timed for 1 minute).
	Subtraction Level 2	It consists of five items that increase in difficulty. Subtraction Level 2 is not given to students who receive a score of zero for Subtraction Level 1. The Subtraction Level 2 problems are the inverse of the Addition Level 2 problems (not timed).
	Word problems	It consists of six items that increase in difficulty. Three of these items use numbers that match three items from the Addition and Subtraction Level 1 subtest. Assessors also keep track of whether the student used one of three problem-solving strategies: finger/tick marks, paper and pencil calculation, or solved problems in his or her head (not timed).

Source: "Early Grade Mathematics Assessment (EGMA) Toolkit" by RTI International, 2014. {International, 2011 #2;International, 2011 #2@@author-year}

Figure 1: PAQUED 2012 Midterm: Grade2 Percent Correct in Number identification by Item and Group



Note: The numbers shown on the x-axis are the actual numbers from the test that the students were asked to identify. Excerpt taken from 'PAQUED: DRC, Projet d'Amélioration de la Qualité de l'Education (PAQUED), Midterm Report, Early Grade Mathematics Assessment (EGMA),' by Brombacher et al., 2012, p.18.

*The symbol indicates that the difference between comparison and treatment estimate is significant.

a sufficient number of items to measure each subtest (RTI International, 2014c).

In EGMA, data can be collected through paper-based instruments or on mobile devices such as tablets, using the RTI-developed Tangerine software (RTI International, n.d). The frequency of assessment varies from one application to another, depending on the purpose of carrying it out.

Reporting and dissemination

In EGMA, results are typically analysed using descriptive statistics, such as mean scores for each subtest and percentage of children scoring zero.

Strategies for disseminating assessment results vary for each EGMA application, but some commonalties can be observed. Typically, EGMA results are compiled in reports and presented to a group of high level education officials, donor agency representatives and subject experts in meetings/forums. Results can be also summarised in policy briefs and brochures to disseminate the results to wider audiences including local education authorities, principals, teachers and parents.

For example, the PAQUED project[5] in the Democratic Republic of Congo used EGMA in order to examine possible program impact on math performance of Grades 2 and 4 students. The subtests included: number identification, number discrimination, missing number, word problems, addition and subtraction. Its mid-term report provided mean scores for each of the EGMA subtests and for each of the target grade, disaggregated by two groups – treatment and comparison. The report also showed the percentage of students who had scored zero (that is, the percentage of students who were not able to respond correctly to a single item in each subtest) for each of the target grades, disaggregated by the treatment and comparison groups. In addition, the item-level performance was reported for each subtest and for each target grade. These data were mostly disaggregated by group (treatment/comparison), gender or province. Figure 1 shows an example of reporting the item-level performance of Grade 2 on the number identification subtest by treatment/comparison groups (Brombacher et al., 2012).

5 The PAQUED (Projet d'Amélioration de la Qualité de l'Education) project is a 5-year initiative that aims to raise students' learning through improved teaching and school environments in the Democratic Republic of Congo. It is funded by USAID and led by Education Development Centre. RTI International designs and implements impact assessments of the program (Brombacher, Davies, Ralaingita, Slade, & Costello, 2012).

In addition to the country level dissemination, implementing countries are encouraged to make their reports and assessment materials publicly available on the USAid website.[6] It aims at sharing their experience with other countries and to reach a broader range of audience at international level.

Influence on policy and practice

Limited information is available regarding how the results of EGMA implementation have influenced educational policy and practice. However, a couple of examples demonstrate how implementing EGMA, often combined with EGRA, can assist setting national benchmarks and targets.

In Ghana, for example, results from EGMA and EGRA of Grade 2 students were used to set national benchmarks for mathematics and reading in the early grades. The purpose of this national study was to provide data that could be translated into an evidence base to inform policy decisions and interventions. A series of workshops brought together education officials, donor agency representatives, and mathematics and language experts to define benchmarks for specific skill areas of mathematics and reading. The results of the benchmarking workshops were presented to high level education officials at the Ghana Education Services' meeting, and the proposed benchmarks for the various subtasks were accepted. The five year targets with respect to the number of pupils achieving the benchmarks and the number of pupils scoring zero on the subtasks were also adopted at the high level meeting (USAID, 2014).

Similar to Ghana, the Ministry of Education in Jordan also hosted a series of workshops for representatives of various ministry departments to set benchmarks and targets for EGMA and EGRA. The benchmarks were based on the results of Grade 2 and Grade 3 Jordanian students in the 2014 National Survey and informed by a range of international benchmarks, the participants' experience with and knowledge of the Jordanian context, and technical support provided by the researchers from RTI (Brombacher, Stern, Nordstrum, Cummiskey, & Mulcahy-Dunn, 2014).

In the Democratic Republic of Congo, EGMA has been used to improve the quality of instruction in mathematics, via the Package for Improving Education Quality (PIEQ). EGMA was adapted to the local context for grades 2, 4 and 6 across 143 sample schools. EGMA was used to establish baseline mathematics skills and monitor change, thereby informing recommendations to the ministry of education about teacher training programs, and to stimulate policy dialogue (Global Reading Network, 2017).

6 https://www.globalreadingnetwork.net/publications-and-research?page=1

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