BMZ Federal Ministry for Economic Cooperation and Development

Early Primary Mathematics Education

in Arab Countries of the Middle East and North Africa

Published by giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

BMZ Federal Ministry for Economic Cooperation and Development

Early Primary Mathematics Education

in Arab Countries of the Middle East and North Africa

Published by giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Foreword

In Rabat, in December 2013, literacy and numeracy in the Middle East and North Africa (MENA) region were at the center of a four-day workshop for education policy makers and representatives of civil society from the region, with inputs from international and regional education experts and presentations of regional good practices.

It was the first regional ‚All Children Learning Workshop' that combined literacy and numeracy. To support the shift from previous 'All Children Reading' workshops to 'All Children Learning', the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ) together with the Islamic Development Bank (IsDB) jointly committed to take the lead on the numeracy track of the workshop.

The initiative forms part of the commitment of BMZ for both, to *"improve the quality of and access to basic education"* (Objective 3, BMZ Education Strategy 2010 – 2013) as well to support the Global Partnership for Education (GPE) in reaching objective three of the GPE Strategic Plan 2012-2015 *"A dramatic increase occurs in the number of children who learning and demonstrating mastery of basic literacy and numeracy skills by grade three"*.

In preparation of the numeracy track of the 'All Children Learning' Workshop, the desk study *'Early Primary Mathematics Education in Arab Countries of the Middle East and North Africa'* was commissioned by BMZ/GIZ and the IsDB. The main findings from the study were presented at the workshop to initiate and support a dialogue on the status quo and the bottlenecks in early mathematics education in the MENA region. We hope that this paper can support further discussions and educational reforms by providing a comprehensive overview of the current situation and key challenges of mathematics education in the MENA region as well as by pointing towards possible ways of overcoming them. In line with the enhanced post-2015 focus on 'learning for all', we hope that the study sensitizes for the challenges that still need to be overcome in early mathematics in order to reach better quality education for all.

The commissioning parties express their gratitude to those who contributed to the development of this paper, in particular to the team of specialist authors Mohammed Matar (Palestine Ministry of Education), Yasmin Sitabkhan (RTI), Aarnout Brombacher (Brombacher and Associates cc and RTI). Special thanks also to Deepa Srikantaiah (GPE) for her advisory contributions as well as to Lena Mächel (BMZ/GIZ Sector Programme Numeracy) for facilitating the entire process and for her technical contributions.

Dr Michael Holländer
GIZ Sector Programme Numeracy

This study was commissioned by the GIZ Sector Programme Numeracy on behalf of the BMZ together with the IsDB. The views expressed are those of the authors and do not necessarily reflect the position of the GIZ, BMZ nor IsDB.

Table of Contents

Introduction

Mathematics is widely recognized as an important mechanism to further education and enables individuals to improve their job market potential. In addition, it is crucial for countries to develop the human capital needed for making advancements in science and technology, which in turn are seen as important factors for economic development. A strong mathematics education makes citizens better problem-solvers and critical thinkers.

The region of the Middle East and North Africa (MENA) has a rich history in the field of mathematics, from the development of the base-10 numeral system that we use today to algebra. Many countries in the MENA region, however, continue to perform poorly in international comparisons. Arab countries in the MENA region that have participated in large-scale assessments such as TIMSS and PISA have consistently fallen at the bottom in terms of performance. In many cases, the average student in low-income countries performs worse than the fifth percentile in high-income countries. In the MENA region, the TIMSS 2011 international assessment of 4th-grade math and science skills showed that none of the ten participating MENA countries achieved above-average scores and, in fact, were the ten lowest performers of all participating countries.

While international assessments have shown that students in Arab countries from the MENA region are struggling, there has been a dearth of information concerning students' mastery of fundamental competencies in the early grades. Recently, the Early Grade Mathematics Assessment (EGMA) was developed in order to provide country-level policy-makers, donors, and practitioners with information concerning the degree to which students are mastering these basic skills. The EGMA, along with assessments developed by ASER in India (Annual Status of Education Report) and UWEZO (its East African equivalent, meaning "capability in Kiswahili"), which target these foundational competencies, have shown that the problem in mathematics starts early—large numbers of students in many low-income countries and low-income populations in the US and OECD countries do not master the foundational math skills that would allow them to succeed in later years. For example, an abbreviated EGMA implemented in one region of Morocco showed that 20 percent of grade two students could not solve any simple addition problems, and 44 percent could not answer any simple subtraction problems (with addends under 10, such as 4 + 2; 4 – 2) (Messaoud-Galusi et al., 2012). In Jordan, children are struggling with conceptual math tasks, with just over 50 percent of children able to solve two-digit addition problems and only 32 percent able to solve two-digit subtraction problems (Brombacher et al., 2012).

Assessments which focus on the early grades[1] indicate that students in Arab countries in the MENA region often do not master the basic competencies. Understanding how students perform in mathematics at the early grades not only helps educators intervene when students may be first encountering problems in mathematics, but performance in early-grade mathematics is also a predictor for later school achievement (Duncan et al., 2007).

Education For All's Goal six to "improve all aspects of the quality of education and ensuring excellence of all so that recognized and measurable learning outcomes are achieved by all, especially in literacy, numeracy and essential life skills"(UNESCO, 2000) has existed for more than ten years, but remains less than fully attained. Approximately 200 million children in primary schools in low-income countries are struggling to read and recognize even basic words and numbers, and repeatedly end up at the bottom of global large-scale skill assessments such as TIMSS, PIRLS, and PISA (GPE, 2013). Mastering reading and numeracy skills at an early age sets the foundation for all future learning and provides opportunities for children to become productive members of society.

Over the last decade, the MENA region has seen significant progress in the education sector. Large investments at the primary level have resulted in a dramatic increase in access to and completion of primary school (GMR, 2012). With some exceptions, MENA countries have largely reached full enrollment rates at the primary level (World Bank, 2008). The region has also made tremendous strides in closing the education gender gap, providing equitable access to primary education for boys and girls (GMR, 2012).

Despite these achievements, large numbers of children in the region fail to understand basic mathematical competencies and as a consequence do not complete primary school or continue in secondary school. The acquisition of basic numeracy skills is important for all children to be able to enter and compete in the labor market once they complete their education, and is the foundation of all "knowledge economy" skills.

MENA countries, therefore, are facing significant challenges in providing access to quality education for children in the early grades. However, it is important to note that the situation in the MENA region is not so different from that in other regions of the Global South: quality and learning are not being achieved. In MENA countries, achievement in math is not only associated with the effectiveness of teaching and learning, but also with providing an equitable system of education for all children.

This paper presents the state of mathematics education in the MENA region and suggests means to improve it according to the pertinent cultural and social context.

1 In this paper "early grades" are defined as Kindergarten to grade three (average ages five/six to eight).

1 State of Early-Grade Mathematics Knowledge in the MENA Region

This chapter presents an overview of the state of knowledge of mathematics teaching and learning in preschool and early grades in the MENA region, highlights the key issues currently being discussed in the literature and in the education sector about mathematics teaching and learning, and shows the trends, with a focus on the topics that are seen as underrepresented or neglected.

Considering the shortage of regional studies analyzing early math class context in MENA schools, this chapter summarizes the teaching and learning outcomes from different MENA countries based on the available findings from TIMSS 2011[2] and the Early Grade Math Assessment (EGMA). The section first focuses on student learning outcomes from TIMSS and EGMA; it then discusses contextual factors from both the TIMSS and EGMA studies: curriculum, assessment use, math in preschool, and teacher readiness to teach.

1.1 TIMSS study in the MENA region

The TIMSS study has been conducted in the MENA region since 1995; this section focuses on results for 4th graders for the last two cycles of TIMSS. The table below lists the mean scores by country from a group of 50 countries. Note that Singapore is included as a comparison as it is ranked number one in 4th-grade mathematics scores.

The mean score of most countries in both years was relatively low. In TIMSS 2011, almost all MENA countries are ranked near the bottom of international lists, and none of these countries reach the International scale centerpoint of 500.

Table 2 below displays the gender disparities in the MENA countries. On average, females outperformed males in the ten out of eleven MENA countries which participated. Such results may raise questions about the "equity" issue in the MENA schools, and may urge researchers to further analyze data to find reasons for such findings.

2 TIMSS 2011 represents the fifth cycle of the Trends in International Mathematics and Science Study (TIMSS), developed by IEA. TIMSS has reported on mathematics and science achievement trends in the 4th and 8th grades, providing educational policymakers, teachers, and researchers with powerful insights into how educational systems are functioning as well as critical intelligence about the possibilities for educational reform and improvement.

Table 1: Trend in math achievement in TIMSS 2011 and TIMSS 2007 for 4th graders

Country/system	Rank out of 50 countries (TIMSS 2011)	Math average score*	
		TIMSS 2011	TIMSS 2007
Singapore****	1	606	599
TIMSS scale centerpoint	–	500	500
Dubai	–**	468	444
Bahrain	41	436	–
UAE	42	434	–
Abu Dhabi	–**	417	–
Qatar	44	413	296
Saudi Arabia	45	410	–
Oman	46	385	–
Tunisia	47	359	327
Yemen + ***	–	348	–
Kuwait	48	342	316
Morocco	49	335	341
Yemen	50	248	224

* The TIMSS mean score is a score standardized with mean of 500 and standard deviation of 100
** Benchmark participants
*** Yemen participated with a sample of 6th graders.
**** Singapore was ranked the first in mathematics out of 59 participants in the 4th-grade sample in 2011 and second in 2007
Source: TIMSS 2011 International Math Report

Table 2: Math achievement in TIMSS 2011 by student gender for 4th graders

Country	Female average scale score	Male average scale score	Gender difference*
Singapore***	608	604	4
International average	490	491	1
Dubai	466	470	4
Bahrain	440	432	7
UAE	438	430	8
Abu Dhabi	425	409	16*
Qatar	420	407	13*
Saudi Arabia	418	402	16
Oman	398	372	26*
Tunisia	363	356	7
Kuwait	358	323	35*
Morocco	338	331	7
Yemen	255	243	12
Yemen +**	354	345	9

* Difference statistically significant.
** Yemen participated with a sample of 6th graders.
*** Singapore was ranked the first in mathematics out of 59 participants in the 4th-grade assessment.
Source: TIMSS 2011 international math report

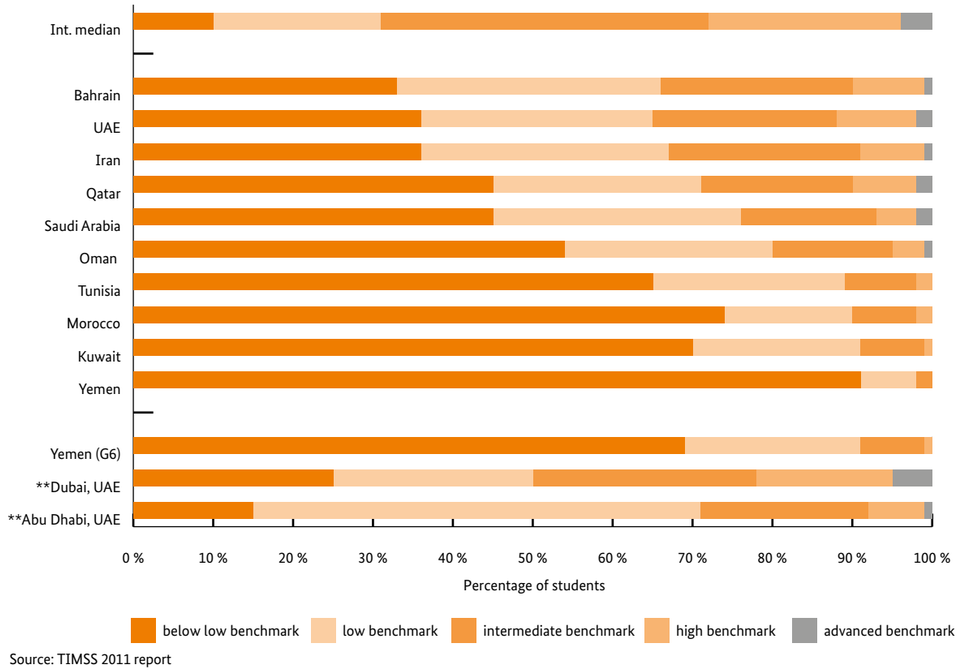
Table 3 below summarizes the TIMSS 2011 international benchmarks for mathematics achievement. These benchmarks give a sense of what 4th graders are expected to be able to do at each benchmark level. Figure 1 illustrates the distribution of 4th graders in each of the participating MENA countries with respect to these benchmarks. What is of concern is the very large number of 4th graders that do not reach the low international benchmark. This suggests that a significant number of 4th graders in the participating countries, and in the case of Oman, Morocco, Tunisia, Kuwait and Yemen the majority of 4th graders, cannot: "add and subtract whole numbers" do not "have some recognition of parallel and perpendicular lines, familiar geometric shapes, and coordinate maps" and are unable to "read and complete simple bar graphs and tables."

Table 3: TIMSS 2011 International Benchmarks of Mathematics Achievement (Grade 4)

Advanced International Benchmark Students can apply their understanding and knowledge in a variety of relatively complex situations and explain their reasoning. They can solve a variety of multi-step word problems involving whole numbers, including proportions. Students at this level show an increasing understanding of fractions and decimals. Students can apply geometric knowledge of a range of two- and three-dimensional shapes in a variety of situations. They can draw a conclusion from data in a table and justify their conclusion.
High International Benchmark Students can apply their knowledge and understanding to solve problems. Students can solve word problems involving operations with whole numbers. They can use division in a variety of problem situations. They can use their understanding of place value to solve problems. Students can extend patterns to find a later specified term. Students demonstrate understanding of line symmetry and geometric properties. Students can interpret and use data in tables and graphs to solve problems. They can use information in pictographs and tally charts to complete bar graphs.
Intermediate International Benchmark Students can apply basic mathematical knowledge in straightforward situations. Students at this level demonstrate an understanding of whole numbers and some understanding of fractions. Students can visualize three-dimensional shapes from two-dimensional representations. They can interpret bar graphs, pictographs, and tables to solve simple problems
Low International Benchmark Students have some basic mathematical knowledge. Students can add and subtract whole numbers. They have some recognition of parallel and perpendicular lines, familiar geometric shapes, and coordinate maps. They can read and complete simple bar graphs and tables.

Source: TIMSS 2011 report

Figure 1: Grade 4 TIMSS performance at International Benchmarks of Mathematics Performance



Source: TIMSS 2011 report

1.2 The Early Grades Math Assessment (EGMA)

Another important source of data regarding early-grade mathematics and numeracy is the Early Grades Math Assessment (EGMA), implemented in Jordan, Iraq, and Morocco in grades two and three. The EGMA provides a picture of children's achievement in many of the foundational domains in early mathematics, including number identification, quantity discrimination, missing number (ability to complete number patterns), addition, subtraction, and word problems. The following table provides the percentage of zero scores by math content domains on the EGMA.

Students in general performed the best on number identification, which relies on largely procedural knowledge; students performed markedly less well on the items that required both understanding and application (e.g., word problems). Although results may indicate a positive progression from grade two to grade three, they do not necessarily indicate a change in the percentage of items answered correctly but instead show that students are getting at least one item correct. The results also show that students still struggled with addition, subtraction, and word problems subtasks.

In Iraq, a nationally representative sample of 1,153 grade two and grade three students from 54 public primary schools across Iraq participated in the study that was conducted during May 2012. A nationally representative sample of 3,120 grade two and three students from Jordan and from 156 public primary schools across Jordan participated in the study that was conducted at the end of May 2012. Below are detailed results from these two countries.

Table 5 summarizes the results by grade on each of the EGMA subtasks for both Jordan and Iraq. While there is some difference in performance between the two countries, the more interesting features of the results

Table 4: Percentage of students with EGMA zero scores, by subtask and grade

Country	Grade	Number identification	Missing number	Addition	Subtraction	Word problems
Jordan	2	1	6	24	48	34
	3	1	5	18	36	22
Iraq	2	2	3	29	61	45
	3	0	0	12	41	21
Morocco	2	2	18	22	44	NA
	3	0	10	9	19	NA

Source: EGMA national reports for Jordan, Iraq, and Morocco

Table 5: Performance by subtask for EGMA in Jordan and Iraq

	Jordan				Iraq			
	Grade 2		Grade 3		Grade 2		Grade 3	
Subtasks	# Correct/ minute	% Correct/ attempted	# Correct/ minute	% Correct/ attempted	# Correct/ minute	% Correct/ attempted	# Correct/ minute	% Correct/ attempted
Number identification	32.1	88.6%	37.8	92.6%	28.1	85.4%	35.5	92.6%
Quantity discrimination	8.7	70.9%	10.6	77.5%	7.5	66.4%	9.4	75.1%
Missing number	4.8	56.6%	6.0	64.8%	3.1	40.0%	4.1	47.5%
Addition (level 1)	13.6	83.6%	14.6	81.6%	9.1	76.5%	13.7	85.6%
Addition (level 2)	2.4	52.7%	2.9	54.8%	1.5	41.5%	2.3	56.8%
Subtraction (level 1)	11.4	79.4%	12.1	75.9%	7.5	69.0%	9.8	82.9%
Subtraction (level 2)	1.3	32.0%	1.8	35.3%	0.6	19.9%	1.0	31.2%
Word problems	–	39.2%	–	52.2%	–	28.4%	–	47.8%

Source: Data drawn from Brombacher et al. (2012). Student Performance in Reading and Mathematics, Pedagogic Practice, and School Management in Jordan and (2012) Iraq

include the following: The difference in performance between the grade two and grade three pupils is not very large – certainly not as much as one might expect to be the effect of an additional year of schooling. In general, there is a clear trend across the countries and grades. The pupils perform better on the more procedural items (number identification and addition and subtraction level one) than they do on the more conceptual items (quantity discrimination, missing number [number patterns], addition and subtraction [level two], and word problems). With the possible exception of the word problems, the gap in performance between grades two and three does not increase on the more conceptual items as might be anticipated based on the expectation that pupils' conceptual knowledge increases with time.

1.3 Early-grade mathematics curriculum

In MENA countries, the math curriculum is set down in various types of official documents, including curriculum frameworks, guides for schools and teachers, student textbooks, and subject syllabuses (or school subject plans in some countries). These curricular documents may address different issues related to math, such as the length of time students are taught math (time on task), math content domains, organization of teaching and the methods used, as well as the forms and criteria of assessment. All these documents make important contributions to student achievement.

The majority of countries in the MENA region have established their math curriculum as a formal document, which is prescriptive. It specifies what topics must be learnt, describes the programs of study and their content, as well as teaching, learning, and assessment materials that should be used. These documents are approved by central educational authorities, and then a team of math experts and educators convert the official documents to student textbooks and teacher guides. In some countries educational authorities import international math curricula and translate the documents into Arabic to be used in their schools. The following table provides more detailed information on math curriculum in MENA countries for which the information was available.

The previous table shows that almost all countries have national mathematics curricula for the primary stage, with some differences in terms of the grades included in the curricula.

The time when the mathematics curricula were developed varies from country to country. In some countries the math curriculum is 14 years old, as in the case of Oman. Other countries have a new math curriculum, as in the case of Egypt, whose math curriculum is only two

Table 6: Characteristics of math curricula for early grades in selected MENA countries

Country	National curriculum for primary education	Grades included	Year introduced	Under revision
Bahrain	No	Grades 1–3, 4–6	2009	Yes
Egypt	Yes	Grades 1–6	2011	NA
Jordan	Yes	Grades 1–10	NA	NA
Kuwait	No	Grades 1–5	2009	Yes
Lebanon	Yes	NA	NA	NA
Morocco	Yes	Grades 1–2, 3–4	2002	Yes
Oman	Yes	Grades 1–4	1999	No
Palestine	Yes	Grades 1–4	2001-2004	No
Qatar	Yes	Grades 1–6	2004	Yes
Saudi Arabia	Yes	Grades 1,2,3,4	2008	Yes
Syria	Yes	Grades 1–4	NA	NA
Tunisia	Yes	Grades 1–2, 3–4	2004	No
UAE	Yes	Grades 1–3, 3–4	2005	Yes
Yemen	Yes	Grades 1–6	2000	Yes
Abu Dhabi	Yes	Grades 1–5	2007	Yes
Dubai	Yes	Grades 1–3,4–5 in public schools, 1–5 in private schools	2005	Yes

Source: TIMSS 2011 Encyclopedia

years old. In some countries, the education system is still struggling to conduct curriculum evaluation, such as in Palestine, Oman, and Morocco, although initial versions were introduced ten years ago or more.

Almost all early-grade math curricula in the region share the same content domains including numbers, geometry, algebra, measurement, and probability and statistics, although with different levels of emphasis (Mullis et al., 2012b).

In Bahrain and Saudi Arabia a translated McGraw-Hill math curriculum was used as a national curriculum. In Jordan, the math curriculum is aligned with the National Council of Teachers of Mathematics (NCTM) standards. In Morocco, the math curriculum is under reform with a focus on three content domains: place value; working numbers and the four operations, plus measurement and geometry. In Palestine, the early-grade math curriculum includes three math content domains: numbers, geometry and measurement, and statistics and probability. In the United Arab Emirates, a new early-grade math curriculum was introduced in 2009, adopting the Scott Foresman–Addison Wesley math textbooks.

To further illustrate the use of curricula in the MENA region, two case studies are presented below that evaluate the respective mathematics curriculum: one of Saudi Arabia and Bahrain, and one of Palestine.
Under the supervision of the Arab Bureau of Education for the Gulf States (ABEGS), there is an initiative aiming at improving the math and science curriculum in two countries: Saudi Arabia and Bahrain. The initiative started in 2006 and ended in 2009, adopting math and science curricula from 1st to 12th graders. Obeikan Education, in alliance with McGraw-Hill Education, provided the Saudi Arabian and Bahrain Education ministries with a full curriculum package, such as student textbooks and platforms that offer support and information to teachers, students, other ministry officials, and math portals.

- After four years of implementing this math curriculum, ABEGS contracted a third party to conduct an evaluation study for the curriculum documents. This evaluation examined the intended (official) curriculum, with no consideration to the operational (implemented) and the attained curriculum. The findings of this evaluation were reported in 2012. Major results focused on the mismatch between the original English versions and the translated Arabic versions and the poorly designed layout. In particular the evaluation study found that after the translation from English to Arabic, many of the higher-order thinking skills and activities were left out. (ABEGS, 2012b).

In Palestine, a full mathematics curriculum from grades one to twelve was developed and gradually introduced to schools. Recently, the Ministry of Education contracted a third party to develop a roadmap for a comprehensive evaluation plan for the curriculum. The third-party group raised important issues in terms of who, when, what, and how to evaluate the curriculum, with a special focus on:

- *Alignment and coherence:* What are the gaps and overlaps within and between subjects?
- *Coordination* between curriculum changes and changes in assessment, supervision and teacher training.
- *Overloading:* There have been some complaints that the curriculum is overloaded, making it difficult for teachers to complete the course on time.
- *Memorization:* concentration on memory to the detriment of higher-order skills.

The curriculum, or more specifically, a central document defining the objectives, learning outcomes, and content for math is adhered to in the vast majority of Arab countries. Most schools are provided with student textbooks and teacher guides that minimize the degree of autonomy of math teachers in organizing teaching and learning in ways that meet the needs of their students.

1.4 National and local assessment tools: formative and non-formative

Effective assessment of student learning is a key component of any successful education system. This section focuses on national-level as well as classroom-level assessment. Research shows that the right kinds of assessment activities, and the right uses of data resulting from those activities, can contribute to better learning outcomes and better-informed policy decisions. It is vital for educators, while striving to improve student learning outcomes, to develop strong systems for assessing students' learning and academic achievement (Clarke, 2011).

Wiliam (2007) described different forms of formative and summative assessments specifically for mathematics classrooms. This focused on ways of providing feedback to students as well as ways in which classroom practice can be adapted to the specific needs in the classroom. Among MENA countries, student assessment takes a variety of forms, instruments and methods, and assessment results are used for different purposes (El Amene, 2013). In the region there are three main types,

each of which serves a different purpose: classroom assessment, national examinations, and large-scale assessments (national and international).

Classroom assessment provides real-time information to support ongoing teaching and learning in individual classrooms on a daily basis. National examinations provide a basis for selecting or certifying students as they move from one level of the education system to the next (or into the workforce). Large-scale assessments provide feedback on the overall performance of the education system at particular grades or age levels-typically they cover a few subjects on a regular basis, using samples, and they may be national or international in scope.

For the national examination, this mainly occurs in the upper secondary stages, as matriculation tests. National examinations do not occur at the early grade level. For the national large-scale assessments, all countries use them with the exception of Iraq, Kuwait, and Libya. Table 7 below provides information on the targeted grade and frequency of the assessment.

Dissemination of results is one of the effective uses of the national assessments. The typical common action is to hold workshops and present the results to the stakeholders as a way to disseminate information on these results while keeping it limited to a selected group. In some countries, such as Palestine, the overall results are published in an annual report (MoEHE, 2012).

Only Jordan, Oman, Qatar, Sudan, and the UAE reported that assessment findings are used by all or most stakeholder groups. Other countries (Bahrain, Egypt, Saudi Arabia, Mauritania, Palestine, and Syria) declared that assessment information is used by some stakeholder groups in a way that is consistent with the stated purposes or technical characteristics of the assessment. Only Lebanon reported that assessment indicators are not used by stakeholder groups or are used in ways inconsistent with the stated purposes or the technical characteristics of the assessment. (El Amene, 2013)

1.5 Math education in preschool

Several studies show that early education paves the way for overall education, and that children who have early education will reach levels much higher than those deprived of it. The "golden first six years" of a child's life form the basis of all progress in the rest of his/her existence (Bennett & Thomas, 2009).

In 2010, the rate of comprehensive coverage for children aged between zero and six years in public childcare centers throughout the MENA region reached about 19 percent, compared to 41 percent of the global rate (AKR, 2011). Children's rates of enrolment in pre-primary education programs vary between one MENA country and another; the rates in Kuwait and the UAE are close to the rate of some developed countries, while the rates in Djibouti, Iraq, Libya, Mauritania, Saudi Arabia, Syria, and Yemen are below the global average (AKR, 2011).

Regarding math education in pre-primary stage in Arab countries, data was collected on student engagement in numeracy activities before primary schools and the effect of such engagement on the students' performance in math. The international findings in this regard show that out-of-school activities like playing with numbers and being taught numbers had greater predictive power for numeracy achievement than any other variables including socioeconomic status (Melhuish et al., 2008). The following table shows the relationship between exposure to early numeracy activities before beginning primary school and math achievement in 4th grade.

The findings in the above table show that an early start in school is associated with higher math achievement, that 4th grade students had higher math achievement if their parents often engaged in early numeracy activities with their children, and that such children started school able to perform early numeracy tasks (e.g., simple addition and subtraction).

Table 7: Early numeracy activities before beginning primary schools and math achievement in 4th grade

Country	Often (doing activities)		Never or almost never	
	% of students	Average achievement	% of students	Average achievement
UAE	45	456	5	404
Qatar	42	436	8	381
Saudi Arabia	37	424	10	387
Oman	26	413	14	359
Morocco	18	338	28	344
Dubai	52	494	5	429
Abu Dhabi	42	439	6	379
International average	49	510	6	460

Source: TIMSS 2011 international report (countries participated in TIMSS 2011 and PIRLS)

1.6 Early-grade math teachers

The problem of low rates of qualified teachers in MENA countries is exacerbated by the fact that some countries have resorted to employing contract teachers, often with less training and experience, for less pay than that received by teachers appointed on a permanent basis by the Ministry of Education (AKR, 2011).

Effective math teaching depends to a large extent on the expertise of teachers, specifically their knowledge of the subject, their understanding of how to teach their subject and of how students learn, and on the quality of their professional training. Early-grade math teachers in the MENA region have different levels of expertise, depending on the pre-service and in-service training they received. The following table provides more information in this regard.

Table 8: Main preparation route and current requirements for early-grade math teachers

Country	Main teacher preparation route	Current requirements			
		Supervised traineeship during teacher education program	Passing a qualifying examination (licensing, certification)	Completion of probationary teaching period	Completion of mentoring/ induction program
Bahrain	Most teachers have a Bachelor of Education or a postgraduate diploma in education following a non-education degree.	No	No	No	No
Jordan	Teachers receive their education through a university degree program.	No	No	No	No
Kuwait	Teachers must have a university degree from the Department of Education, or any equivalent university degree.	Yes	No	Yes	Yes
Lebanon	NA	NA	NA	NA	NA
Morocco	Most teachers have a general university diploma and then complete a teacher training course.	Yes	Yes	Yes	Yes
Oman	All teachers receive their education through a university degree program.	Yes	No	No	Yes
Palestine	Most teachers receive their education through a university degree program.	No	Yes	Yes	No
Qatar	Teachers must have a university degree in primary education, with many having specialized majors in the subject they teach.	No	No	No	No
Saudi Arabia	Most teachers have attended a teacher college program, though some teachers receive their education through a university program.	Yes	Yes	No	No
Syria	Most teachers receive their education through a university program.	Yes	Yes	No	No
Tunisia	Most teachers qualifying for university entrance must then successfully pass an exam to attend a training period before starting to teach.	Yes	Yes	Yes	No
UAE	Most teachers receive their education through a university program.	No	Yes	Yes	No
Yemen	Teachers must have a university degree.	Yes	No	Yes	No
Abu Dhabi	All public school teachers have a university degree. As of recently, teachers are required to have an education degree or teaching certificate.	Yes	No	No	No
Dubai	Most teachers have a qualified background in teaching and a teaching certificate.	By school type	By school type	By school type	By school type
Singapore	All primary school teachers are required to undergo pre-service teacher education. They can obtain either a two-year diploma in Education, a four-year Bachelor of Arts/Science or a one- or two-year postgraduate diploma in education.	Yes	Yes	Yes	Yes

Source: TIMSS 2011 Encyclopedia

Mathematics teacher quality stands as a key issue in the educational reform initiatives. Some countries have conducted evaluation activities targeting mathematics teachers and mathematics supervisors; in Bahrain, the MoE conducted a diagnostic test for senior mathematics teachers, supervisors, and curriculum specialists. This test aimed at providing indicators about the quality of mathematics teachers in terms of their acquisition of content and didactic knowledge, such indicators help establishing a strategic plan for teacher in-service and pre-service training programs, for the sake of enhancing mathematics instruction and improving student performance.

Oman participated in the "Teacher Education Study in Mathematics" (TEDS-M) (Tatto et. al., 2012), a cross-national study intended to provide data on the knowledge that future primary and lower-secondary mathematics school teachers acquire during their mathematics teacher education. It is also the first major study to examine variations in the nature and influence of teacher education programs within and across countries. The study determined an anchor point for Mathematics Pedagogical Content Knowledge (MPCK) for the lower-secondary level. They determined that scores above 509[3] indicated teachers that were likely to have some knowledge of the lower-secondary curriculum and of planning for instruction.

3 The TEDS-M mean score is a score standardized with mean of 500 and standard deviation of 100.

2 Early Mathematical Competencies

The early grades are when students should be mastering basic mathematical competencies, which are the foundational competencies that form the base for more complex mathematics. In this section, we review what these competencies are and discuss what it means to do mathematics successfully in the primary grades.

Children enter primary school with a large array of informal mathematical understandings. There is research highlighting how mathematics is intuitive to very young children. For example, infants have an inherent number sense through subitizing (Dehaene, 1997, Devlin 2010, and Sousa, 2008). Devlin (2010) writes, "human babies as young as two days after birth exhibit an innate knowledge of basic arithmetic facts [such as:] $1 + 1 = 2$, $1 + 2 = 3$, $1 - 1 = 0$, $2 - 1 = 1$, $3 - 1 = 2$, $3 - 2 = 1$, $2 - 2 = 0$, $3 - 3 = 0$" (p. 165). Infants are also able to quantify small groups of objects, can discriminate between set sizes in objects, and engage in simple arithmetical thinking (Cooper, 1984; Sophian & Cooper, 1987; Starkey & Cooper, 1980; Wynn, 1992).

There is also a large body of research that examines "preschool" mathematics, or the informal mathematics that children develop before they begin primary school. Ginsburg et al. (1998) define informal mathematics as "grounded in problem-solving situations with concrete objects, and children construct it through their interactions with the physical and social world" (p. 413). As children begin to manipulate their physical world around them, they develop new mathematical understandings (Ginsburg & Opper, 1998). For example, young children begin counting objects in their world around them. They also combine and separate sets of objects, and begin to see the effect that combining and separating has on the sets. Children develop qualitative means to distinguish between set sizes; for example, children may visually determine that one group of objects has more than another group of objects. In addition to the development of numeracy, pre-primary children also begin to develop ideas about geometry, patterns, and measurement. They notice shapes, and develop ways of categorizing these shapes (Clements, 2004). They can extend simple patterns and begin to identify patterns in their world. Young children also use perceptual clues to determine which of two objects is longer than the other (Clements & Stephan, 2004).

As children transition to primary school, however, their informal understandings cannot intuitively be translated into more formal mathematical skills (Resnick, 1992). Formal mathematics "entails the manipulation of a system of written symbols, and children typically acquire this type of mathematical knowledge in school" (Ginsburg et al., 1998, p. 413). Consider a young child that has learned how to count five objects, for example. Although the child may be able to say that there are five objects in the set, it is not until formal schooling that he or she learns how to connect the five objects with the written numeral "5." Another young child may know that if he or she has 3 cookies and eats one cookie, there are now only 2 cookies left. However, not until formal schooling does the child learn that he or she can express that problem with the statement $3 - 1 = 2$.

Formal mathematics is a cultural construction developed throughout history, and relies on instruction (Bruner, 1976; Saxe, 1991; Vygotsky, 1978). Children do not acquire formal mathematical ideas intuitively. It is important to have a well-planned sequence of instruction that builds from children's informal mathematics.

What can this instruction look like, and what areas should be considered? To answer this, we first discuss what it means to "do mathematics" at the primary level. We then detail the foundational competencies of early mathematics.

2.1 Strands of proficiency

The National Research Council (2001) published a summary of what it means to be successful in elementary-school and middle-school mathematics. They detail five strands of mathematical proficiency: (1) understanding, (2) computing, (3) applying, (4) reasoning, and (5) engaging. Each of these strands is interwoven. The report emphasizes that all strands must be taken into account when thinking about mathematical proficiency.

Understanding is defined as "Comprehending mathematical concepts, operations, and relations – knowing what mathematical symbols, diagrams, and procedures mean" (p. 10). In short, it is not enough to be able to

produce correct answers. Doing mathematics means understanding what is being done, and why. For example, consider the equation 3 + 4 = 7. A child must understand what quantity each numeral represents. At the same time, he or she must also understand the symbols "+" and "=". It is important that a child understands that the plus sign means that you are adding sets together to produce larger sets. The equals sign means that the equation is balanced, and what is to the right is equal to what is on the left.

Computing is defined as "Carrying out mathematical procedures, such as adding, subtracting, multiplying, and dividing numbers flexibly, accurately, efficiently, and appropriately" (p. 11). There is not one correct way to solve a problem, and children should have multiple strategies for different types of problems. In addition, children should be able to choose and apply the strategy that is most appropriate. For example, consider the problem 29 + 30. This problem can be solved using an algorithm where the numbers are lined up vertically and then solved first in the ones column, then the tens column. Alternatively, you can count by tens, starting at 29, then 39, 49, and 59. There is not just one way to solve a problem, and multiple strategies should be emphasized. Accurate computing is not in isolation from understanding; understanding and computing are deeply interwoven, and lend support to each other.

Applying is the ability to use understanding and computing to be able to solve problems. When faced with mathematical problems, children should be able to use what they know about a particular domain and apply it to a new context to solve the problem. As children develop more sophisticated mathematical ideas, they also begin to define mathematical problems and choose the most appropriate means to solve them. When given word problems, for example, a child can analyze the problem and then choose the most suitable operation(s) and strategies for solving the problem.

Mathematical reasoning is "the glue that holds mathematics together" (National Research Council, 2002, p. 14). While solving problems, children must be able to understand what they are doing, reflect on their answer and solution path, justify their answer and solution path, and then apply their solution to new problems and new domains. For example, children that are learning to understand and become fluent with basic addition facts can explain why, if they know that 9 + 9 = 18, 9 + 8 is one less than 18. They can then apply this new pattern that they have discovered to other addition problems.

Engaging refers to children's personal views and ideas about mathematics. They should see mathematics as something that is useful to them and makes sense. Children should not see mathematics as a set of rules to be followed, and where correct and incorrect answers are seen as being determined by the teacher and not the mathematics itself. They should want to learn mathematics and persist in learning mathematics.

These five strands of proficiency are crucial if we want children to develop a strong foundation of mathematical competencies in the early grades. Each strand relates intimately to the other four strands, and none of them stands alone. Mathematics education should strive to develop proficiency in all strands through a program that focuses on both instructional strategies and core domains of knowledge.

2.2 Core domains of knowledge

We now turn to the research base on the basic mathematical competencies that children learn in primary school, focusing on what the competencies are and how they are developed. To organize this section, we drew from the Learning Metrics Task Force, which has recently detailed focal outcomes for primary school mathematics (Learning Metrics Task Force, 2013). They are: number concepts and operations, geometry and patterns, and mathematics applications. Below, we focus on (1) number concepts, (2) operations, (3) geometry, (4) measurement, and (5) mathematics applications. Because we view patterns as integrated in all areas of mathematics, we discuss patterns within each domain below.

2.2.1 Number concepts

"Number concepts" signifies a conceptual understanding of numbers, also referred to as "number sense." Number sense enables students to easily relate theoretical mathematical concepts of numbers and numerical expressions to the applications in the real world, and vice versa (Case, 1998). It also is a key ingredient to solve basic arithmetic computations (Gersten & Chard, 1999). Number concepts include understanding the "quantity" of a number and being able to represent it abstractly and in different ways.

Research has established that a core component of number sense is counting. Counting is guided by the "how-to-count" principles (Gelman & Gallistel, 1978). The principles are:

- One-to-one correspondence, where a child assigns one number word to one object when counting.
- Stable order, where there is a stable order to the list of number words. For example, in English, the words are "one, two, three, four," etc.

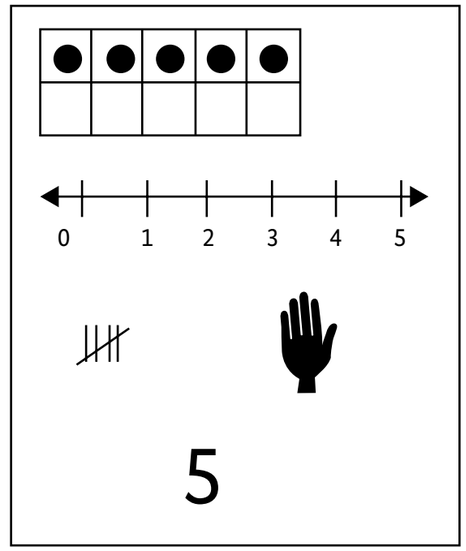
- Abstraction refers to the idea that all objects can be counted.
- Cardinality is the understanding that the last number word in the count refers to the total number of objects.
- Order irrelevance is the idea that objects in a set can be counted in any order. This is unlike reading, where there is prescribed directionality.

All of these principles must be in place in order to successfully count a set of objects and determine how many objects there are. When children arrive in primary school, they often have experience with some of these principles. Through formal schooling, they begin to link the counting principles to written numerals as well as use counting to solve more complex problems. Magnitude is also a core component of number sense. Number systems are precisely that: systems of relationships and patterns amongst numbers. These relationships are defined by magnitude. For example, consider the numbers 5 and 6: 6 is one greater than 5, and 5 is one less than 6. Understanding and being able to manipulate these relationships is important for children's development of number sense.

Another facet of our number system is place value. Place value allows us to write numerals for all possible numbers using only nine digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. In Figure 1 below, the Arabic numerals from 0 to 9 are shown. The place of the digit is integral in the base-10 number system. For example, the numerals 32 and 23 are different because of the placement of the 3 and the 2. In 32, the 3 is in the tens place, and represents 30. The 2 is in the ones place, and represents 2: 30 plus 2 equals 32. As children are introduced to written numerals, they may first learn how to write and read the numerals between 0 and 9, and then see how combining the numerals in different ways allows them to write numerals above 9. An understanding of place value is integral to developing fluent and flexible number sense.

In order to develop a strong number sense, children need varied and repeated opportunities to count (both objects and rote counting), to compare quantities, and to see relationships and patterns between numbers. In addition to whole numbers, children can be exposed to common fractions in the early grades. Children should also become familiar with and use multiple representations in different ways. Figure 2 below details examples of common representations for a number, including a tens frame, number line, tally marks, fingers, and written numeral. All of these are different ways to represent the quantity of five. Exposure to a variety of representations helps build conceptual understanding of number.

Figure 2: Common representations for the number 5



2.2 Operations

Operations deal with combining and separating quantities. In the primary grades, operations commonly include addition, subtraction, multiplication, and division. Often, we define an understanding of operations as a child's ability to quickly and accurately solve addition, subtraction, multiplication, and division facts, such as 3 + 4, and 5 × 7. However, at the primary level, it is important to first focus on the conceptual understanding of what the operations mean (Ginsburg et al., 1998; Resnick, 1983). For example, children should learn what occurs when two sets of objects are put together, or taken apart in different ways. They should learn about the relationship between various operations, such as addition and subtraction. They should also learn about properties of operations, such as the commutative and additive properties. A strong focus on conceptual understanding includes one on multiple strategies for solving problems. Children should be flexible with numbers and strategies, and choose the best strategy for solving a particular problem.

A focus on multiple strategies also supports children gaining automaticity, or the ability to quickly recall basic facts with speed and accuracy (Ginsburg et al., 1998; Baroody et al., 2009). Automaticity with basic facts may be constructed by children using derived facts (Carpenter & Moser, 1982). For example, 7 + 4 = 11, so 7 + 5 must be 12 since 5 is one more than 4. Children also develop automaticity through generating rules.

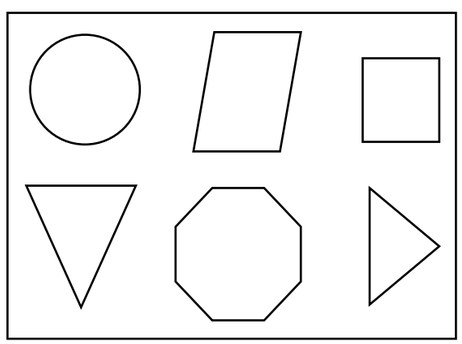
Children may, for example, generate the rules about adding 0, or multiplication by 1 (Baroody, 1993). To do this, a child may see a pattern where adding 0 to a number always results in the original number (i.e., 2 + 0 = 2; 3 + 0 = 3; 100 + 0 = 100). From this pattern, they generate the rule that when adding 0 to a number, the result is always the original number. Through repeated practice, children eventually come to solve basic operations with fluency. There is a large body of research that details how fluency in the addition of one-digit numbers is a core competency of early-grade mathematics (Baroody, 1987b; Jordan et al., 2003; Reikeras, 2006). Children's ability to quickly recall the basic facts reduces working memory demands, which can be used to solve more complex problems (Tolar et al., 2009).

When learning operations, an often-used progression begins with addition, then subtraction, then multiplication, and then division; however, research does not support such a linear path. Instead, operations can be viewed as cycles. Children may begin with problems with smaller numbers that are contextualized and refer to concrete objects. These problems can include all four operations. As children begin to understand the meaning of operations, abstract symbols may be introduced, and children can move back and forth between the concrete level and the abstract level. With increased practice and exposure as well as encouragement to use multiple strategies, children may become fluent with the basic facts while at the same time using these basic facts to solve more complex problems.

2.2.3 Geometry and patterns

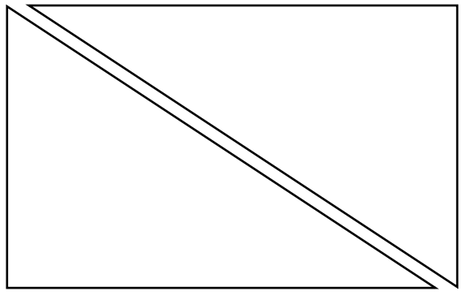
In the early grades, much of geometry consists of the analysis of shapes (see Figure 3) and their attributes, beginning with classifications made primarily on visualization, and slowly proceeding to analysis and abstraction of rules for shapes (Van Hiele, 1968).

Figure 3: Common shapes in primary geometry



Children also learn to see similarities and differences between shapes. For example, children may come up with ways to describe the difference between a rectangle and a square. They may analyze different types of triangles (e.g., isosceles, right, equilateral). Children also explore the effects of rotating shapes in different ways. They combine and separate shapes to create new shapes, for instance combining two right triangles to make a square as seen in Figure 4. (Common Core State Standards, 2012). These skills are foundational to later geometric concepts, such as volume, congruence, and symmetry (Clements, 2004).

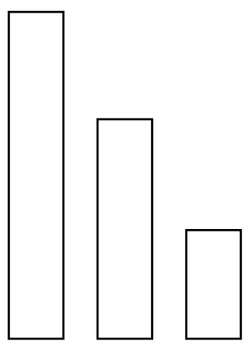
Figure 4: Combining shapes



2.2.4 Measurement

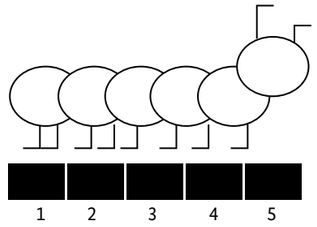
Children learn to compare measurable dimensions of objects, moving from qualitative comparisons to quantitative comparisons during the primary school years. Initially, children may perceptually compare attributes of objects (e.g., length, weight, height) and categorize them as "equal" or "not equal" (Boulton-Lewis et al., 1996). They also begin to use other vocabulary, such as "longer," "shorter," and "heavier" when comparing objects such as the sticks in Figure 5.

Figure 5: Sticks to use for comparisons



As they progress throughout primary school, children begin to employ quantitative terms to compare objects. Non-standard measurement uses a unit to measure one or two objects, and then either compare them or assign a numeric value to an object. For example, children may use rocks, leaves, or sticks to measure objects, as seen in Figure 6 below, where the caterpillar is being measured using blocks. At this point, children begin to understand that although you can use any object to measure any other, the objects (i.e., units) must be the same. Children also learn that units can be iterated and subdivided (Clements & Stephan, 2004). Standardized measurement builds on the principles learned from non-standard measurement. Children begin to use rulers and the standardized measurement system of their country to compare objects and then quantify their measurable dimensions.

Figure 6: Non-standard measurement using blocks



2.2.5 Mathematical application

Mathematical application is inherent in all the focal areas described above. In fact, the beauty of formal mathematics is that it allows us to consider a contextualized situation, abstract it, and then generalize those abstractions to a new situation to solve a different or more complex problem. In turn, the new problem may provide insights and thus enhance the existing understandings.

A key component of mathematical application deals with estimation. Estimation is an important skill both to solve increasingly complex problems and as a tool when applying mathematical skills to contexts outside of the mathematics classroom. Halberda et al. (2008) note that people who approximate numbers quickly and accurately are more successful in advanced mathematics. In certain contexts, approximate answers are required instead of exact answers. Calculators and computers also provide a means to solve complicated problems, and estimation is vital in double-checking the reasonableness of answers. Estimation also supports children's development of fluency and flexibility with numbers.

The five core competencies (number sense, operations, geometry, measurement, and mathematical application) tell us what curriculum and intervention efforts should focus on teaching in the early grades. They also suggest how instruction should be organized. Together, they provide a picture of what early mathematics programs in the MENA region can look like.

3 Country-Specific Initiatives

This chapter provides an overview of interventions that are being undertaken by governments and others globally and in the region, and summarizes where such activities stand in terms of advancement and evidence of impact.

The chapter highlights the promising approaches for instruction, assessment, instructional materials, and use of mobile education and teacher training in the Arab-speaking world, focusing on approaches that are implemented on different levels of intervention (macro, meso, micro).

The MENA region has a history in education improvement programs, both country-specific and region-specific. Beginning in the late 1960s, there was a worldwide movement to improve mathematics education in which many Arab states participated (Jurdak & Jacobsen, 1981; Jurdak, 1991; Malaty, 1980).

3.1 Country- and regional-level reform

3.1.1 ARAIEQ: An umbrella educational initiative

Improving the quality of education is one of the most important and urgent challenges for the future of the Arab world. This was acknowledged at the Doha Colloquium on Quality Education for All in September 2010. Eighteen Arab countries were represented, twelve of them with their Ministers of Education in attendance. They agreed that there are serious challenges concerning the quality of education in the Arab world and it is urgent to take action. This was reflected in the endorsement by all participating countries of a Doha Declaration on Quality of Education in the Arab World (Annex 1). The Doha Declaration by Arab Ministers of Education requested that ALECSO, the Qatar Foundation and the World Bank propose an action plan to develop a programmatic response to the Ministers' mandate.

As a result, the Arab Regional Agenda for Improving Education Quality (ARAIEQ) was developed as an umbrella initiative aimed at tying a number of current programs and institutions together into a coherent framework.

ARAIEQ aims to provide the initial knowledge base, instruments, and expertise to improve the quality of education in the region by establishing effective national assessment systems and subsequently building capacity to use this data for continuous policy development, working in conjunction with a regional program on teacher policies and teacher professional development; it will also entail systematic curriculum innovation, incorporating ICT into teaching and learning processes and focusing on the curriculum. It will also entail ensuring the necessary school readiness through national policies and institutions of early childhood development, with an emphasis on entrepreneurship to prepare students for the job market. Numeracy and early-grade math are an important part of ARAIEQ, particularly in terms of research activities, curriculum, ICT utilization, teachers, early childhood, and entrepreneurship.

3.1.2 ABEGS Improvement of math and science curriculum

In 2008, the Arab Bureau of Education for the Gulf States (ABEGS) launched an initiative titled "Improving the mathematics and science curriculum" as a tool for developing teaching and learning for the two subjects. Saudi Arabia, Bahrain, and Kuwait were involved in the first initiative, and other Gulf states were invited to benefit from this project.

The main objective of this project was to adopt translated versions of a mathematics and science curriculum for grades one to twelve developed by an international publishing company (McGraw-Hill) in partnership with Obeikan Company. Two countries used the translated textbooks, while other Gulf countries adopted other mathematics textbooks series or developed their own. To evaluate the student textbooks used in this project, Obeikan Company contracted a third party. Results of this evaluation were not encouraging, although the evaluation considered only the written textbooks, not the operational curriculum. Moreover, even though the adopted curriculum had been used since 2008, the impact of the project on the student outcomes (as measured by TIMSS 2011 in the two countries) was not remarkable.

Another project was the Regional Network for Education Policy Analysis Initiative: from Evidence to Policy sponsored by the World Bank and ISESCO, and hosted by the National Center for Human Resources Development (NCHRD) in Jordan. The initiative was launched in June 2009. Seven countries in the Middle East and North Africa (MENA) participated for three years: Dubai, Jordan, Lebanon, Oman, Palestine, Syria, and Tunisia.

The initiative consisted of a series of learning seminars and mentoring activities aimed at building national capacity in participating countries to analyze, present, and disseminate data on student learning and performance, and also to provide policy makers with evidence to formulate policies related to learning and teaching math and science. Each country had a national research team working on national TIMSS data to develop research questions. Based on these questions, trainers from the World Bank introduced advance statistical techniques to be able to provide an answer based on the TIMSS data.

The World Bank, in conjunction with NCHRD experts, also conducted mentoring visits to some countries to support national teams and to raise commitment at the national level. These countries developed a policy note based on the analyses, which was then presented to policymakers to develop a plan of action that may help educational reform activities. Many of the research themes tackled were related to math education issues, such as gender differences in mathematics scores (policy note of Jordan), factors associated with high performance in mathematics (policy note of Palestine), the impact of educational intervention on mathematics achievement (policy note of Tunisia), and the impact of curriculum development on mathematics achievement (policy note of Dubai, 2012).

The main challenge to this initiative was the issue of sustainability: how to utilize the initiative to enhance the approach of using assessment findings to inform policy. In this regard, the initiative was not able to sustain the work, despite the plans for follow-up.

3.1.3 Mobile learning: Expand the reach and equity of education

Today, mobile technologies are common even in areas where schools, books, and computers are limited. As the price of cell phones continues to decline, more and more people, including those in extremely poor areas, are likely to own and know how to use a mobile device.

One of the new educational interventions that start growing globally is mobile learning through the use of mobile technology, either alone or in combination with other kinds of information and communication technology (ICT). The major benefit of mobile learning is that learning is possible anytime and anywhere, through access to educational resources, connection with others, and creating shared content both inside and outside classrooms. An added benefit is improved communication between schools and families (UNESCO, 2013).

Mobile learning also facilitates personalized learning by providing immediate feedback and assessment, ensuring the productive use of time spent in classrooms, enhancing seamless learning, bridging formal and informal learning, minimizing educational disruption in conflict and disaster areas, assisting learners with disabilities, and maximizing cost-efficiency.

While designing mobile learning projects to increase educational access, two key issues must be addressed: access to mobile devices and Internet connections, and sustainability. In this regard, global organizations ranging from UNESCO to industry associations such as GSMA and corporations like McKinsey & Company are investing significant resources into exploring how the ubiquity and rapidly expanding functionality of mobile technologies can be leveraged to promote learning. As these efforts continue, more examples of successful mobile learning projects will be available as models for educators, policymakers, and others.

3.1.4 Teacher Education Improvement Project (TEIP): Having teacher ready to teach

Building on the fact that the "quality of an education system can't exceed the quality of its teachers" (McKinsey, 2010) the Ministry of Education in Palestine initiated a four-year intervention in 2010 funded by the World Bank.

The prime objective of the intervention is to improve the competencies and skills of teachers for teaching Grades one to four (early grades), for the sake of enhancing students' learning in primary schools. The target population of the intervention is future teachers that are being prepared to become class teachers as well as underqualified teachers currently teaching Grades one to four. The intervention consists of two components:

Component 1: Strengthening "school-based practice" of teacher education programs. This component supports the establishment of a system of context-based practical experiences in schools as a central part of the program of studies.

Component 2: Upgrading academic and professional teaching qualification of underqualified class teachers. Teachers will be eligible to obtain a Class Teacher Professional Certificate (CTPC), which makes their qualifications equivalent to that of a licensed teacher graduating from an accredited teacher education program.

The project is still in progress and there is no final report on the work. Early indications are, however, that the task is not easy and that it is made harder by among other things the full Grade one to four curriculum and teacher education programs that struggle to prepare teachers for this in the time available. This task is made even more challenging by the fact that Grade one to four teachers tend to be class teachers responsible for all subjects and not mathematics specialists. In other words, the time spent in teacher training has to be shared by all of the subjects for which the teacher is being prepared.

3.1.5 Country-specific reforms

In Qatar there has been a recent focus on student-centered classrooms through the government sponsored "Education for a New Era" project, which began in 2003. The project promotes "deep conceptual learning, knowledge construction and intellectual autonomy" (www.education.gov.qa). However, evaluations of this project have not produced the desired results (Said & Friesen, 2013; Ikhlef & Knight, 2013). Ikhlef & Knight (2013) conducted a comprehensive study in Qatar focused on independent elementary schools implementing elements of the reform movement. They used classroom observations as well as surveys of teachers (n = 67) and students (n = 1,150). The findings of the study revealed that there was no systematic evidence of the new goals of the "Education for a New Era" being implemented in schools. Although teachers were disposed to the new methods of teaching, they did not have the skills needed to implement the new methods. The authors call for more teacher professional development to support teachers in changing their practice. Said & Friesen (2013) found that, despite the new emphasis on education in Qatar, there was diminished interest and competence in mathematics and science at the secondary and tertiary levels, and they call for the need to reinvigorate students' engagement in mathematics and sciences.

In the wake of the EGMA study in Jordan, the Ministry of Education (with technical support from USAID in Jordan) has embarked on a one-year pilot intervention research project. The pilot study involves some 12,000 children across nearly 300 Grade one, two and three classrooms in 45 schools and across twelve education districts.

Rather than to revise the entire curriculum and/or attempt to change the approach to teaching reading and mathematics in the early grade classrooms, the approach of the pilot intervention has been to introduce a short 15-minute routine into the daily reading and mathematics lesson. The purpose of the routine is to address the gaps identified by the national survey in the early grade reading and mathematics skills of Jordanian students and, at the same time, expose teachers to alternate teaching methodologies and approaches without asking them to change everything that they do all at once.

The purpose of the daily routine in mathematics is to support children in developing a more robust sense of number. This means specifically:

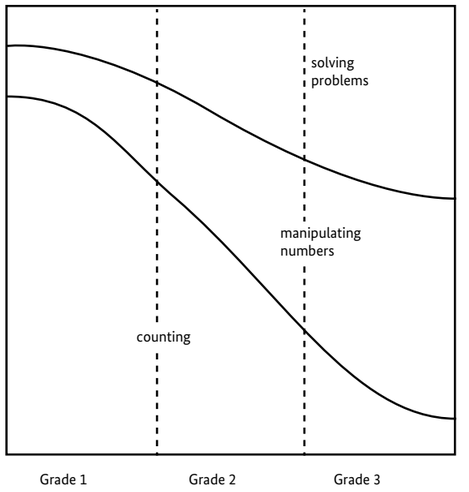
- Being able to work fluently and flexibly with numbers and number concepts;
- Having a rich understanding of the meaning of number; and
- Having a wide range of effective strategies for solving a variety of number problems.

The daily mathematics routine in the Jordan pilot intervention involves three distinct but interrelated elements: counting, manipulating numbers, and solving problems. The amount of time allocated to each element of the routine varies according to the developmental state of the children. In Grade one the children will do more counting and solving problems and less manipulating numbers, while in Grade three the focus will be more on manipulating numbers and problem solving and less so on counting (see Figure 7).

For each of the three different components of the daily routine, there is a series of different activities that the teacher may use. The activities will vary in terms of complexity (including number range) depending on the developmental state of the children.

The counting component of the routine includes the activities listed below. Taken together, the activities

Figure 7: Distribution of time allocated to elements of the routine across the grades



create a developmental trajectory that supports the development of counting over the three years from Grade one to Grade three.

Rote counting activities:

- Counting in ones
- Counting rhymes and songs
- Counting in steps

Rational counting activities:

- Counting small sets of counters in ones
- Counting out small groups of counters
- Estimating and counting larger sets of counters in ones
- Counting in groups
- Counting large sets of counters in groups

The materials for the pilot intervention in Jordan consist of three different publications: the teacher manual, the daily lesson notes, and a workbook with a daily written activity for the students. Each of the activities for each of the components of the routine is described in the teacher manual. The teacher manual is used to convey to teachers the purpose of the activities in terms of their role in developing a strong sense of number as well as to explain how to conduct each activity as part of the daily routine in the classroom. The daily lesson notes indicate which activity to perform in each of the segments of the daily routine and provide some specific details for the activities of the day. For example, if the students are to count a large pile of counters using groups, the lesson notes will suggest to the teacher an appropriate number of counters to be counted and the size of the groups to be used in counting the counters. Finally, there is a set of workbooks for the students. The workbooks contain a page for each day of the semester with a counting, manipulating numbers, and problem solving activity. The written activities in the workbook match the activities conducted by the teacher and the class during the 15-minute routine, thus reinforcing the concepts being developed on that day.

The classroom implementation phase of the project involved the following stages:

- The training of the supervisors to both supervise and support the introduction of the program in the schools, and to train the teachers.
- The training of the teachers. It was conducted by the supervisors who were in charge of the teachers implementing the program in their schools.
- The implementation of the program in the sampled schools by teachers. This phase is supported by the supervisors, who visit the teachers once every two weeks.

The program has been running in schools for more than ten weeks up until now. Apart from the supervisor reports by supervisors on their visits to classrooms, there is early anecdotal evidence to suggest that despite the shift in practice that the routine represents, teachers are finding that children are responding well to the activities. They are surprised to discover just what the children are capable of doing. In particular, the teachers are responding with enthusiasm to the different ways that numbers can be manipulated with and how this is supporting children in developing a stronger number sense. Before the end of the 2013/2014 school year, another national survey (including EGRA and EGMA) will be conducted in the same 156 schools as in the 2012 survey, and the impact of the intervention in the 45 pilot schools with respect to pupil performance on foundational mathematics competencies will be evaluated.

Another study in Jordan aimed to understand why children's mathematics performance was consistently low (Jarrah, 2013). It focused on Jordanian pre-service mathematics teachers and investigated their beliefs about learning mathematics. The author found that 65 percent of teachers "believed that the best way to learn mathematics is to memorize all the formulas" (Jarrah, 2013, p. 92). He calls for more teacher support and professional development to help teachers re-envision the goals and purposes of elementary mathematics.

3.2 Key actors

This section enlists some of the key actors in early-grade mathematics and numeracy issues in the MENA region. In the Arabic-speaking world various

organizations are engaged in education more generally as well as in early-grade mathematics education in particular. Three of the most influential regional organizations are listed below:

The **Islamic Educational, Scientific and Cultural Organization (ISESCO)** has national offices in each member country. Education forms one important element of ISESCO's agenda. Twenty-two Arab countries and twenty-nine Islamic non-Arab countries are represented in ISESCO. (http://www.isesco.org)

The **Arab League Educational, Cultural and Scientific Organization (ALECSO)** is a specialized agency that works within the Arab League. ALESCO is mainly concerned with enhancing and coordinating educational and cultural activities in the Arab world. Education forms one important topic of the ALECSO agenda. Twenty-two Arab countries are represented in the organization. (http://www.alecso.org)

The **Arab Bureau of Education for the Gulf States (ABEGS)** follows all educational activities at the sub-regional levels and focuses on the teaching of math and science. Seven Gulf states are represented in this organization. (http://www.isesco.org)

At the national level, with regional and international networks, five institutions are well known for their engagement in education issues and educational reform initiatives. All of these five institutions are cooperating with ALECSO and the World Bank. They are listed below:

The **UNESCO regional office**, Beirut, used to participate and initiate regional events tackling a broad spectrum of educational topics with a focus on policy issues concerning the quality of education. (http://www.unesco.org/new/en/beirut)

The **Queen Rania Teacher Academy (QRTA)**, Jordan, focuses on teacher education and training issues. The academy works with several Arab countries to develop an Arab teacher profile and regional policies as well as interventions for quality teachers in the region. (http://www.qrta.edu.jo/)

Injaz Al Arab, Jordan, promotes a culture of entrepreneurship and business innovation among Arab youth. The institution operates in twelve countries across the Middle East and North Africa region. Injaz Al Arab collaborates with corporate volunteers and Ministries of Education to provide Arab youth with professional qualifications to enable them to succeed in the global economy. (http://www.injazalarab.org)

Arab Resource Collective (ARC), Beirut, focuses on early child care and education. ARC collaborates with ALECSO for the improvement of education quality in pre-school and kindergarten services. (http://www.mawared.org/)

The **National Center for Education Technologies (CNTE)**, Tunisia, collaborates with North African Arab countries in the use of ICT in education. CNTE is now hosting the Arab Program on Curriculum Innovation, Qualifications, and ICTs in Education within ARAIEQ. (http://www.cnte.tn)

Some private or semi-governmental organizations are also engaged in educational issues in the region. Some of the most active organizations that could contribute to the improvement of early-grade math and numeracy are the following:

The **Qattan Centre for Educational Research and Development (QCERD)** is part of the Qattan Foundation. The QCERD aims to assist teachers in the acquisition of new skills and improve their knowledge base through applied research and professional development. (http://www.qattanfoundation.org/en/about-qcerd)

In the UAE, the **Mohammed bin Rashid Al Maktoum Foundation** was established in 2007 to develop knowledge and human resources to form a new generation of leaders that is qualified to support overall development in the Arab region. (http://www.sheikhmohammed.co.ae)

The **Qatar Foundation** was established to prepare young people for the challenges of a rapidly changing world. It sponsors programs in science and research and supports a group of educational institutions known for their well-developed programs in various learning phases. (http://www.qf.org.qa/education)

Obeikan Investment Group: Obeikan Education provides fully integrated educational solutions to serve the development of a curriculum and teaching methods, in addition to e-learning and technology learning. The organization partners with reputable educational providers worldwide, such as McGraw-Hill Education, Cambridge University, Teaching Strategy International, SMART, and Laureate Education. The chair of Sheikh Abdul Rahman Al-Obeikan for math and science education at King Saud University is one of the active constituents of the group. (http://www.obeikan.com.education; https://c.ksu.edu.sa/ocsme)

At the individual level some experts may also be regarded as key actors in numeracy education. Please refer to Annex 2 for details on resource persons from Arab NRCs for TIMSS 2011 (Table 9) and members of the UNESCO Assessment and Evaluation Research Team (Table 10).

4 What Can Be Done in the MENA Region to Address the Learning Gaps?

The data points to the need for a comprehensive reform in the teaching and learning of early mathematics in the MENA region. Below we provide several key recommendations for instruction, textbooks, parental and community involvement, and use of ICTs.

4.1 Instruction

1. Efforts should be made to strengthen instructional methodologies which promote active learning, critical thinking, and applying mathematics in real-life situations. Particular attention should be paid to methods to develop children's conceptual knowledge of early mathematics.
2. More research is needed about current promising practices in early-grade mathematics instruction in the MENA region using classroom observations and teacher interviews. This research can provide a starting point for the development of new interventions.

4.2 Mathematics textbooks

1. Develop regional learning goals based on findings from TIMSS and EGMA as well as other regional and national assessments. These goals should address, among others: concepts such as "mathematics for life", 21st-century skills, learning how to learn, high-order thinking skills, and a student-centered learning approaches in this regional learning framework.
2. Developing textbooks and other teaching and learning materials appropriate to the classroom contexts that translate the goals and visions for mathematics education into effective classroom activities.
3. Pilot textbooks, focusing on student learning outcomes as well as classroom practice measures.
4. Start an in-depth longitudinal study that investigates the relationship between the intended, the implemented, and the attained curriculum in order to identify mismatches.

4.3 Community and parental involvement

1. Empower parents and community members to count, play number games, and integrate mathematics into their everyday activities with children. For example, mathematical activities to be integrated, such as shopping in a market, running errands, counting money, counting objects around the house.
2. Parents and community should make efforts to make math engaging by demonstrating to children how they use math in their everyday lives and emphasizing that math is useful and necessary.
3. Drilling children on math facts is not the best use of a parent's time. Although it is not harmful, it would be better to engage children in mathematical thinking and problem solving.

4.4 Teacher Professional Development

1. Analyze the education programs for early-grade pre-service mathematics teachers as well as in-service professional development programs to establish whether these programs are aligned with new trends in early grade mathematics instruction.
2. Integrate teacher education programs with real, practical sessions in schools.
3. Ensure that such programs are promoting teachers' mathematical teaching knowledge.
4. Develop appropriate mechanisms for teacher appraisal, monitoring, and evaluation if needed, using classroom observation, e.g. through other math teachers or the headmaster/headmistress.
5. Implement the Survey of Initial Teacher Education Programs (SITEP)[4] in some MENA countries to collect further and up-to-date data on early-grade math teachers in those countries.

4 http://eacea.ec.europa.eu/education/eurydice/SITEP.php

6. Enhance action research activities among early grade math teachers to help teachers further understand teaching and learning in the classroom context.
7. Enhance teacher cooperation, collaboration, and exchange using ICT means.

4.5 Policy

1. Conduct more regional assessments of early-grade mathematics performance to develop a more holistic sense of the performance by pupils on the foundational mathematics skills.
2. Create an awareness of the need to prioritize early-grade mathematics and to place it firmly on the regional agenda. Reform is resource-intensive and therefore requires decisions in allocating resources for early-grade math reform programs.
3. Communicate a clear vision of what it means to learn mathematics in the early grades and then support those involved in the creating and implementation of national curricula; pre- and in-service training of teachers and the development of teaching and learning materials in the translation of this vision into practice.
4. Set performance indicators for each reform to be able to evaluate and measure the impact on classroom learning and teaching.
5. Ensure continual monitoring and evaluation mechanisms so the best impact on learning and teaching can be achieved.

List of Abbreviations

ABEGS	Arab Bureau of Education for the Gulf States
AIR	American Institute for Research
AKR	Arab Knowledge Report
ALECSO	Arab League Educational, Cultural and Scientific Organization
ARAIEQ	Arab Regional Agenda for Improving Education Qualitys
ARC	Arab Resource Collective
ASER	Annual Status of Education Report
BMZ	German Federal Ministry for Economic Cooperation and Development
CNTE	National Center for Education Technologies
EGMA	Early Grade Mathematics Assessment
EGRA	Early Grade Reading Assessment
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
IEA	International Association for the Evaluation of Educational Achievement
ILSA	International Large-Scale Assessments
IRC	International Research Conference
ISESCO	Islamic Educational, Scientific and Cultural Organization
KSA	Kingdom of Saudi Arabia
LMTF	Learning Metrics Task Force
MENA	Middle East and North Africa
MENIT	Middle East Network on Innovative Teaching and Learning
MoE	Ministry of Education
NCHRD	National Center for Human Resources Development
NCTM	National Council of Teachers of Mathematics
OECD	Organization for Economic Cooperation and Development
PIRLS	Progress in International Reading Literacy Study
PISA	Program for International Student Assessment
QCERD	Al-Qattan Center for Educational Research and Development
QRTA	Queen Rania Teacher Academy
SABER	System Assessment and Benchmarking for Education Results
SSME	Snapshot for School Management Effectiveness
TALIS	Teaching and Learning International Survey
TEDS-M	Teacher Education Study in Mathematics
TIMSS	Trends in International Mathematics and Science Study
UAE	United Arab Emirates
UIS	UNIESCO Institute of Statistics
UNRWA	United Nations Work and Relief Agency
USAID	United States Agency for International Development
UWEZO	“Capability in Kiswahili” (East African equivalent of ASER)

References

ABEGS (2012a). Evaluation Report and Forms: Mathematics. Final report. http://www.abegs.org/sites/GMO/DocLib1/Math/index.html

ABEGS (2012b). Evaluation of the Gulf State Math and Science Textbooks: Summary. Final report. http://www.abegs.org/sites/GMO/DocLib1/Suammer/index.html#/1/zoomed

Adams, A., & Winthrop, R. (2011). The role of education in the Arab World revolutions. Brookings Institution.

Arab Knowledge Report [AKR] (2011). Preparing Future Generations for the Knowledge Society.

Atieh A (2008). Gulf States Experiences in Developing Teaching Strategies. ABEGS Publications. (In Arabic)

Baroody, A. J. (1987b). The development of counting strategies for single-digit addition. Journal for Research in Mathematics Education, 18(2), 141-157.

Baroody, A. J. (2009). Fostering early numeracy in preschool and kindergarten.Encyclopedia of language and literacy development, 1-9.

Baroody, A. J. (1993). Fostering the mathematical learning of young children.Handbook of research on the education of young children, 151-175.

Bennett J & Thomas C (2009). Early Childhood Education and Care in Dubai. Executive Summary. Prepared for KHDA.

Boulton-Lewis, G. M., Wilss, L. A., & Mutch, S. L. (1996). An analysis of young children's strategies and use of devices for length measurement. The Journal of Mathematical Behavior, 15(3), 329-347.

Brombacher A, Collins P, Cummiskey C, Kochetkova E, Mulcahy-Dunn A (2012). Student Performance in Reading and Mathematics, Pedagogic Practice, and School Management in Jordan.

Carpenter, T. P., & Moser, J. M. (1982). The development of addition and subtraction problem-solving skills. Addition and subtraction: A cognitive perspective, 9-24.

Case, R. (1998, April). A psychological model of number sense and its development. In annual meeting of the American Educational Research Association, San Diego.

Common Core Standards Writing Team. (2013). Progressions for the Common Core State Standards in Mathematics (draft): K. Counting and Cardinality; K-5 Operations and Algebraic Thinking. Institute for Mathematics and Education, University of Arizona: Tucson, AZ.

Cooper, R.G., Jr. (1984). Early number development: Discovering number space with addition and subtraction. In C. Sophian (Ed.), The origins of cognitive skills. Hillsdale, NJ: Erlbaum.

Clarke M (2011). What Matters Most for Student Assessment Systems: A Framework Paper. The World Bank.

Clements, D. H., Sarama, J., & DiBiase, A. M. (Eds.). (2004). Engaging young children in mathematics: Standards for early childhood mathematics education. Routledge.

Clements, D. H., & Stephan, M. (2004). Measurement in pre-K to grade 2 mathematics. Engaging young children in mathematics: Standards for early childhood mathematics education, 299-317.

Dehaene, S. (1997). The number sense: How the mind creates mathematics. Oxford University Press.

Devlin, J C (2010). Challenges of economic development in the Middle East and North Africa region. Singapore; Hackensack NJ: World Scientific.

EdDataII (2012). Iraq Education Surveys–MAHARAT, Executive Summary: Analysis of Student Performance in Reading and Mathematics, Pedagogic Practice, and School Management. RTI International prepared for USAID/Iraq.

EdDataII (2012). Student Performance in Reading and Mathematics, Pedagogic Practice, and School Management in Jordan. RTI International prepared for USAID Jordan.

El Amene A (2013). Survey of Student Assessment Systems: MENA Regional Mapping Report. UNESCO publications. (In press.)

EURYDICE (2011). Mathematics in Europe: Common Challenges and National Policies. EACEA P9 Eurydice.

Gelman, R., & Gallistel, C. R. (1978). The child's understanding of number. Cambridge, MA: Harvard, University Press.

Gersten, R., & Chard, D. (1999). Number Sense Rethinking Arithmetic Instruction for Students with Mathematical Disabilities. The Journal of special education, 33(1), 18-28.

Ginsburg, A., Leinwand, S., Decker, K. AIR (2009). Informing Grades 1–6 Mathematics Standards Development: What Can Be Learned From High-Performing Hong Kong, Korea, and Singapore? American Institutes for Research.

Ginsburg, H. P., Klein, A., & Starkey, P. (1998). The development of children's mathematical thinking: Connecting research with practice. In D. Kuhn & R. S. Siegler (Eds.), Handbook of child psychology (5th ed., Vol. Two: Cognition, Perception, and Language, pp. 401-468). New York: John Wiley & Sons, Inc.

Ginsburg, H. P., & Opper, S. (1988). Piaget's theory of intellectual development. Prentice-Hall, Inc.

Halberda, J., Mazzocco, M. M., & Feigenson, L. (2008). Individual differences in non-verbal number acuity correlate with maths achievement. Nature,455(7213), 665-668.

Hattie J (2009). Visible Learning: a Synthesis of over 800 Meta-Analyses Relating to Achievement. London: Routledge.

Ikhlef, A., & Knight, S. L. (2013). Conditions for student-centered teaching and learning in Qatari elementary math and science classrooms: Relationship between classroom processes and achievement of curriculum standards. Near and Middle Eastern Journal of Research in Education, (2013).

Jarrah, Adeeb M. INVESTIGATION OF JORDANIAN PRE-SERVICE TEACHERS'BELIEFS ABOUT LEARNING AND TEACHING OF MATHEMATICS. Diss. University of Missouri-Kansas City, 2013.

Jordan, N. C., Hanich, L. B., & Kaplan, D. (2003). A longitudinal study of mathematical competencies in children with specific mathematics difficulties versus childrenwith comorbid mathematics and reading difficulties. Child Development, 74(3), 834-850. doi: 10.1111/1467-8624.00571'

Jensen B (2012). Catching up: Learning from the Best School Systems in East Asia. Grattan Institute Publications.

Jensen B (2012). Catching up: Learning from the Best School Systems in East Asia. Grattan Institute Publications.

Jurdak, M., & Jacobsen, E. (1981). The evolution of mathematics curricula in the Arab States. Studies in mathematics education, 2, 133-47.

Jurdak, M. (1991). Teachers' conceptions of math education and the foundations of mathematics. In PME CONFERENCE (Vol. 2, pp. 221-228). THE PROGRAM COMMITTEE OF THE 18TH PME CONFERENCE.

Kilpatrick, J., Swafford, J., & Findell, B. (Eds.). (2001). Adding+ it up: Helping children learn mathematics. National Academies Press.

Lietz P, Wagemaker H, Neuschmidt O, Hencke J. (eds.) (2008). Educational Issues in the Middle East North Africa Region. IEA Training Seminar Series 2006/2007. IEA Publications

Malaty, G. N. (1980). The reform movement in mathematical curricula in Egypt and the UNESCO mathematics project for the Arab States. European Journal of Science Education, 2(4), 449-455.

McCormack R (2010). Nokia "MoMath" Mobile Learning Project Empowers SA Learners.

Mckinsey & Company (2007). How the World's Best-Performing School Systems Come Out on Top.

Mckinsey & Company (2010). Closing the Talent Gap: Attracting and Retaining the Top-Third Graduates to Career in Teaching.

Melhuish EC, Phan MB, Sylva K, Sammons P, Siraj-Blatchford I, Taggart B (2008). Effects of the Home Learning Environment and Preschool Center Experience upon Literacy and Numeracy Development in Early Primary School. Journal of Social Issues, 64 (1), 95–114.

Miura, I. T., Okamoto, Y., Kim, C. C., Steere, M., & Fayol, M. (1993). First graders' cognitive representation of number and understanding of place value: Cross-national comparisons: France, Japan, Korea, Sweden, and the United States. Journal of Educational Psychology, 85(1), 24.

Mullis I, Martin M, Foy P, Arora A (2012a). TIMSS 2011 International Results in Mathematics. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

Mullis I, Martin M, Minich C, Stanco G, Arora A, Centurino V, Castle C (2012b). (Eds). TIMSS 2011 Encyclopedia: Education Policy and Curriculum in Mathematics and Science. IEA Publications.

Mulkeen A (2013). Consultancy to Palestinian MoE: Support the Development of a Plan for Curriculum Reform. In press.

LMTF (Learning Metrics Task Force). 2013. Toward Universal Learning: Recommendations from the Learning Metrics Task Force. Montreal and Washington, D. C.: UNESCO Institute for Statistics and Center for Universal Education at the Brookings Institution.

NCHRD (2012a). Jordan Policy Note. Regional Network for Education Policy Analysis Initiative.

NCHRD (2012b). Oman Policy Note. Regional Network for Education Policy Analysis Initiative.

National Research Council (2001). Adding it up: Helping children learn mathematics. J. Kilpatrick, J. Swafford, and B. Findell (Eds.) Mathematics Learning Study Committee, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: National Academy Press.

Reikeras, E. K. L. (2006). Performance in solving arithmetic problems: a comparison of children with different levels of achievement in mathematics and reading. European Journal of Special Needs Education, 21(3), 233-250. doi: 10.1080/08856250600810633

Resnick, L. B. (1992). From protoquantities to operators: Building mathematical competence on a foundation of everyday knowledge. Analysis of arithmetic for mathematics teaching, 19, 275-323.

Resnick, L. B. (1983). Mathematics and science learning: A new conception of Science.

RTI International (2009). Early Grade Mathematics Assessment (EGMA): A Conceptual Framework Based on Mathematics Skills Development in Children.

Said, Z., & Friesen, H. (2013). QATARI STUDENTS PERFORMANCE, INTEREST IN, AND ATTITUDE TOWARDS SCIENCE AND MATHEMATICS. EDULEARN13 Proceedings, 3345-3353.

Saxe, G. B. (1991). Culture and Cognitive Development. Hillsdale, NJ: Lawrence Erlbaum Associates.

Sousa, D. A. (Ed.). (2008). How the brain learns mathematics. Corwin-volume discounts.

Starkey, P., & Cooper, R. G. (1980). Perception of numbers by human infants.Science.

Tolar, T. D., Lederberg, A. R., & Fletcher, J. M. (2009). A structural model of algebra achievement: computational fluency and spatial visualisation as mediators of the efect of working memory on algebra achievement. Educational Psychology, 29(2), 239-266. doi: 10.1080/01443410802708903

UNESCO (2006). EFA Global Monitoring Report 2007. Paris: UNESCO Publications

UNESCO (2008). EFA Global Monitoring Report 2009: Overcoming Inequality: Why Governance Matters). Paris: UNESCO Publications (in Arabic).

UNESCO (2010) Early Childhood Stage in Arab Countries: Facts and Challenges. Paris: UNESCO Publications (in Arabic)

UNESCO (2012). Turning On Mobile Learning, Illustrative Initiatives and Policy Implications. By Shafika Isaacs. Paris: UNESCO Publications

UNESCO (2012). Education for All Global Monitoring Report Youth and Skills: Putting Education to Work. Paris: UNESCO Publications

UNESCO (2013). Policy Guidelines for Mobile Learning. Paris: UNESCO Publications

Tatto M, Peck R, John S, Kiril B, Sharon L, Michael R, Lawrence I, Mark R, Glenn R (2012). Policy, Practice and Readiness to Teach Primary and Secondary Mathematics in 17 Countries: Findings from the IEA Teacher Education and Development Study in Mathematics (TEDS-M).

Van Hiele, P. M. (1959). The child's thought and geometry. English Translation of Selected Writings of Dina van Hiele-Geldof and Pierre M. van Hiele. ERIC/SMEAC. In Carpenter, TP, Dossey, JA, & Koehler, JL (Eds.)(2004). Classics in mathematics education research. Reston, VA: National Council of Teachers of Mathematics.

Vygotskij, L S (1978): Mind in society. The development of higher psychological processes. Cambridge: Harvard University Press.

Wiliam D (2007). Keeping on Track: Classroom Assessment and the Regulation of Learning. In: F.K. Lester, Jr. (ed.) Second Handbook of Mathematics Teaching and Learning. Greenwich, CT: Information Age Publishing, 1053–98.

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving*. Journal of child psychology and psychiatry, 17(2), 89-100.

World Bank (2006). West Bank and Gaza. Education Sector Analysis: Impressive Achievements under Harsh Conditions and the Way Forward to Consolidate a Quality Education System. Washington, DC: The World Bank

World Bank (2008). "The Road Not Traveled: Education Reform in the Middle east and Africa," MENA Development Report. Washington, DC: The World Bank

Wynn, K. (1992): Addition and subtraction by human infants. Nature, 358(6389), 749–750.

The Authors

Dr. Mohammed Matar

Mohammed Matar is Director of the Assessment and Evaluation Department at the Ministry of Education Palestine. His career focus and research interests focus on assessment and evaluation of children's learning, particularly in mathematics as well as in the cost-benefit analyses of different approaches to mathematics instruction. He is committed to the inclusion of mathematics education in the early learning agenda. Dr. Matar was part of the team for the development of the first math curricular for Palestine.

Mohammed Matar works as TIMSS National Research Coordinator in Palestine since 2004. He also coordinates the national assessment activities in Palestine and a study on learning outcomes for United Nations Relief and Works Agency (UNRWA) schools in Palestine.

Mohammed Matar supervises the evaluation of education programs in Palestine and other Arab countries. He is a member of the scientific advisory board (SAB) for the Arab agenda for improving the quality of education (ARAIEQ).

He is also member of the International Association for the Evaluation of Educational Achievement (IEA) General Assembly and a member of the regional Learning Measurement Task Force for developing the universal Frameworks for Measuring Learning. Mohammed Matar is research coordinator for Early Grades Reading Assessments in Palestine and Yemen.

Aarnout Brombacher

Aarnout is currently the project leader on a pilot reading and mathematics intervention in Jordan that is targeting 300 teachers across 45 schools. Working with RTI Aarnout has been involved in national studies of early grade mathematics performance using the EGMA in a range of African and Middle Eastern countries including Iraq, Jordan, Nigeria, Egypt, Malawi and the DRC.

Aarnout established an educational support company in South Africa that conducts teacher training, develops materials and provides research solutions in mathematics education with a particular focus on the early grades.

Aarnout was a member of the TIMSS International Expert Panel.

Yasmin Sitabkhan

Yasmin Sitabkhan is a research education analyst in RTI's Teaching and Learning group in the International Education Division. Dr. Sitabkhan has spent the past 13 years in the field of education, beginning as a primary school teacher and charter school administrator after which she transitioned to the role of a researcher in India, Mexico, and the United States. Her research interests build directly on her experiences as a classroom teacher, in which she focuses on instructional strategies to connect informal and formal mathematics. Dr. Sitabkhan has worked on numerous research projects that promote a deeper understanding of teaching and learning at the primary school level. Her research has explored the mathematical competencies of groups of marginalized children in developing countries (Mumbai, India and Oaxaca, Mexico) through qualitative and quantitative methods. She has also contributed to a design research project at UC Berkeley, in which she worked on developing mathematics curriculum and instructional methods. In her role at RTI, Dr. Sitabkhan is currently providing technical expertise in early grade mathematics instruction to projects around the world. She trains on the implementation and theoretical backgrounds of the Early Grade Mathematics Assessment (EGMA) and provides support for the implementation of early math materials in Liberia.

Annex 1

Doha Declaration on Quality of Education for All

We, the Ministers of Education in the Arab world, meeting in Doha, Qatar on 21–22 September 2010, after our consideration of the issues and challenges related to quality education, and sharing the belief that improving it is crucial for our societies as they seek to achieve comprehensive and sustainable development and access to the knowledge society, Stress:

- That quality of education is the capacity of education systems to provide learners with the knowledge, skills, competencies and ethical and citizenship values which enable and qualify them to be active citizens.
- Improving quality of education always requires a long road of reforms, strong and consistent political leadership and sustained and predictable financing. Such a long process entails the following:

F. Access to learning for all according to the principles of equity and equal opportunity.
G. Ensuring that students can progress through the different types and levels of schooling while having the opportunity to choose among different education and training paths;
H. Providing adequate inputs that themselves meet quality standards, such as school infrastructure, textbooks and teachers;
I. Student interaction with these inputs within an environment that offers supportive policies, relevant curriculum, effective teaching methods, and internal monitoring and evaluation systems;
J. Reinforcing student readiness to learn through an enabling family, community and school environment;
K. Restructuring education governance with the participation of all stakeholders in order to achieve a flexible system characterized by autonomy, accountability and clear and transparent education policies; and
L. Monitoring and evaluating student learning regularly so that relevant information and feed-back can be provided to stakeholders and decision makers.

- Improving education quality is the highest-impact and most cost-effective national investment for any country in the Arab World, regardless of its level of economic development and income.
- The benefits resulting from successful educational reform far outweigh its costs, whatever its size, considering that the high economic output and returns of improving the performance of human resources reduce the impact of economic fluctuations and cyclical crises.
- The extra attention that needs to be provided to children living in emergency and special situations is also required in order to achieve quality of education for all.

Based on these considerations, and as an affirmation of our belief in the importance of quality in education and our willingness to ensure it, we commit to work on:

- Making quality the core of education reforms, its ultimate goal and the objective that all actors in the education process should aim to achieve through;
  - Building a comprehensive system of quality assurance geared towards improving the performance of all Arab schools.
  - Establishing quality national standards for all dimensions of the education system, particularly for teachers and other education professionals.
- Placing evaluation systems at the service of quality assurance through:
  - Establishing national monitoring and evaluation systems based on objective data and quantitative and qualitative indicators to measure student learning and school performance. This data will then be used by teachers to improve their performance, help decision-makers in making well-informed choices, and inform the community on the outcomes of the resources allocated to schools;
  - Building capacity of human resources in the field of quality and its monitoring and

evaluation, and providing them with the necessary competencies to design and develop assessment mechanisms and tools as well as advanced methods of data analysis;
- Disseminating a culture of quality, evaluation and accountability in education, where the data on the functioning and outcomes of the education system is made publicly available to all stakeholders;
- Establishing a joint Arab evaluation system and regional research program on education quality, developing benchmarks and regional databases through the collaboration between the Arab Observatory for Education and the Ministries of Education and other specialized institutions, as well as supporting ALECSO to publish a yearly report on the status of education in the Arab World;
- Promoting and extending the collaboration among Arab countries in the education sector in order to strengthen the sharing of information, experience and expertise, and the implementation of joint programs;
- Requesting ALECSO to prepare an Action Plan, in collaboration with the World Bank and Qatar Foundation, for the implementation of the provisions made in this Declaration on Quality of Education. This Action Plan should include specific monitoring mechanisms and tools, and it shall be submitted to the next annual meeting of the Arab Ministers of Education.

Decision of Regional Ministers to endorse ARAIEQ

Decision No.: 15 ق /20 م ع/د ع

A Decision Regarding the Arab Program for Improving Education Quality

The General Conference,
Making reference to the education development plan in the Arab World, and Doha Declaration on Education for All, and Having perused the document submitted No.: 15 ق /20 م ع/د ع and related attachment, and based on relevant discussions,
Decided:
1. Adopting the Arab Program for Improving Education Quality as mentioned in the attachment to the document submitted by the Director General to the General Conference; and
2. Authorizing the Director General to take actions required to implement this program.

The General Conference: Session 20: Muharam 1432 A.H. Dec. 2010.

Illegible handwriting: For approval Mr.....[sic]

Annex 2

The **TIMSS National Research Coordinators (NRCs)**. Each TIMSS participating country designates an individual to be the TIMSS NRC. This position involves tasks related to the implementation of TIMSS in the country. TIMSS NRCs coordinate TIMSS implementation with the IEA, the TIMSS & PIRLS International Study Center, the IEA Data Processing and Research Center, and Statistics Canada.

The following table provides information about TIMSS 2011 NRCs in the Arab countries:

Table 9: Arab NRCs for TIMSS 2011[5]

Country	NRC name	Employer
Bahrain	Huda Al-Awadi	Ministry of Education (MoE)
Jordan	Khattab M. Abulibdeh	National Center for Human Resources Development
Kuwait	Marzouq Al-Ghonaim	Ministry of Education
Lebanon	Leila Maliha Fayad	Educational Center for Research and Development, MoE
Morocco	Mohammed Sassi	Centre Nationale de l'Evaluation et des Examens
Oman	Zuwaina Al-Maskari	MoE
Palestine	Mohammed Matar	Assessment and Evaluation Department, MoE
Qatar	Abdulsattar Nagi	Supreme Education Council
Saudi Arabia	Saleh Alshaya	International Studies & Testing Center (ISTC), MoE
Syria	Omar Abou Awn	MoE
Tunisia	Kameleddine Gaha	National Center for Pedagogical Innovation and Research
UAE	Nada Abu Baker Ruban	Assessment Department, MoE
Yemen	Tawfiq Al-Mekhlafy	Educational Research and Development Center, MoE
Abu Dhabi	Shaikha Ali Al Zaabi	Abu Dhabi Education Council
Dubai	Mariam Al Ali	Knowledge and Human Development Authority
Source: IEA homepage		

5 As of November 2013

Other key actors in the region are the researchers in the UNESCO mapping study for assessment systems in the Arab countries. They are enlisted below:

Additional sources of information that may help any future reform regarding early-grade math are the free websites specialized in teaching and learning early-grade math. Selected sites are listed in Annex 2.

Table 10: Assessment and Evaluation Research Team[6]

Country	Researcher	Employer/e-mail
Bahrain	Maher Aldarabi	MoE, memnmyd@moe.gov.bh
Egypt	Hasib Abdrabou	National Center for Examinations and Educational Evaluation, drhasib2010@yahoo.com
Iraq	Hala Ibrahim Majid	Quality Assurance Department, MoE, dr.salamtareq@yahoo.com
Jordan	Sheren Hamed	Researcher, National Center for Human Resources Development, SherenH@nchrd.gov.jo
KSA	Saleh Zahrani	General Evaluation Supervisor, MoE, sz2000z@gmail.com
Kuwait	Sarah I. Portman	National Center for Education Development, namtrop@hotmail.com
Lebanon	Charlotte Hanna	Center for Educational Research and Development, channa@crdp.org
Libya	Anies Hroub	American University of Beirut, aa111@aub.edu.lb
Mauritania	Jean Jarousse	jpjarousse@hotmail.com
Oman	Mohamed Al Hadidi	Educational Assessment , MoE, mymath@gmail.com
Palestine	Mohamed Matar	MoE, momatar66@yahoo.com
Qatar	Maha Saadi	Supreme Education Council—Evaluation Institute, m.alsaadi@sec.gov.qa
Sudan	Fayza Khalafallah Md	Directorate of Examinations, MoE, fayza500@hotmail.com
Syria	Almouthana Khodour	Curricula and Supervision, MoE, Mothana_khadour@yahoo.com
Tunisia	Al Hedi Al Saidi	General Directorate of Studies, planning and Information Systems—MoE, hedi.saidi@minedu.edunet.tn
UAE	Awatif Bu Afra	MoE, Awatefh@moe.gov.ae
Yemen	Nour Eddin Akil	Sector of Training and Formation, MoE, nor.aqeel@yahoo.com

Source: UNESCO mapping report

Websites with Rich Information and Free Math Activities

3. The **Math Forum** (www.mathforum.com): resources for students, parents, and teachers
4. **Math World Interactive** (http://mathforum.org/mathworld/): open-ended word problems for students
5. **Math Flashcards** (www.edu4kids.com/): online flashcards with a variety of options and mathematical operations
6. **U.S. Department of Education, Office of Educational Research and Improvement** (www.ed.gov/pubs/parents/)
7. **Education Place** (www.eduplace.com): a wealth of worksheets and online activities
8. **National Council of Teachers of Mathematics (NCTM)** (http://illuminations.nctm.org/): lesson plans and math tools based on CTM's Principles and Standards for School Mathematics
9. **MathMastery.com** (www.mathmastery.com): online math courses, daily math activities, and resources you can purchase.
10. **PBS Teacher Source and PBS Kids** (www.pbs.org): resources for teachers, kids, and parents connected to children's favorite PBS shows
11. **Math Goodies** (www.mathgoodies.com): offers worksheets, software, and puzzles for download
12. **FunBrain.com** (www.funbrain.com): math games for children practicing math skills right at the computer

6 As of November 2013

Published by
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn,
Germany

Sector Programme Numeracy
Education Section
Division of Education, Health and Social Protection

Godesberger Allee 119
53175 Bonn
Germany
Tel. +49 (0) 228 44 60 - 0
Fax +49 (0) 228 44 60 - 1766

Dag-Hammarskjöld-Weg 1-5
65760 Eschborn
Germany
Tel. +49 (0) 6196 79 - 0
Fax +49 (0) 6196 79 - 1115

numeracy@giz.de
www.giz.de/numeracy

In cooperation with
the Islamic Development Bank

Authors
Dr Mohammed Matar (Palestine Ministry of Education, lead author)
Dr Yasmin Sitabkhan (RTI International, lead author)
Aarnout Brombacher (Brombacher & Associates and RTI International)

Design and Layout
Diamond media GmbH, Neunkirchen-Seelscheid
Cheryl Juhasz

Printed by
druckriegel GmbH GmbH, Frankfurt/Main, Germany
Printed on FSC-certified paper

Photo credits
© GPE / Deepa Srikantaiah

As at
December 2013

GIZ is responsible for the content of this publication.

On behalf of
Federal Ministry for Economic Cooperation and Development (BMZ)
Education Division

Adresses of the BMZ offices

BMZ Bonn
Dahlmannstraße 4
53113 Bonn
Germany
Tel. +49 (0) 228 99 535 - 0
Fax +49 (0) 228 99 535 - 3500

BMZ Berlin
Stresemannstraße 94
10963 Berlin
Germany
Tel. +49 (0) 30 18 535 - 0
Fax +49 (0) 30 18 535 - 2501

poststelle@bmz.bund.de
www.bmz.de