Basic Education curriculum effectiveness in East Africa: A descriptive analysis of primary mathematics in Uganda using the 'Surveys of Enacted Curriculum'

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Abstract

For most school-going children in many developing countries of Sub-Saharan Africa today for whom schooling is not translating into actual learning, the question regarding the true value of education remains unanswered. Can the use of descriptive curriculum analytics impact teachers' in-class instructional decisions as to lead to improved opportunities for children's learning? Recent evidence from citizen-led annual learning assessments conducted in the three East African countries of Kenya, Tanzania and Uganda reveal extremely low learning gains as children progress through school, starting in the very early grades where they are expected to acquire foundational competences. Whereas several factors have been studied, there is shockingly very little evidence on basic education curricula effectiveness in East Africa. Twaweza East Africa has adapted the 'Surveys of Enacted Curriculum' SEC framework to analyze basic education curricula effectiveness in the region. In this study, we developed a subject taxonomy for primary-level Mathematics in Uganda – one of four core learning areas – and analyzed the distribution of relative emphases in the standards, classroom instruction, and assessments. We conclude that the lack of nationally-agreed well-thought subject-specific comprehensive taxonomies likely translates into content coverage inconsistencies that might deter achievement of planned progressive learning across grades. We find no clear evidence of a systematic emphasis structure on developing learner performance expectations as they progress across grades. Our analyses also reveal low alignment indices between standards and national assessments, and between standards and classroom instruction. Finally, we find evidence of content delivery disparities between lower primary teachers in rural versus urban school settings, which disparities likely disadvantage rural children from early on thus making it hard for them to master the basic competences required for progress to higher grades

Keywords

Primary mathematics; Curriculum Standards; Classroom instruction; Standardized assessments; Opportunity to learn.

JEL I20, I21

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1.0 Introduction

Whereas a significant number of primary school-aged children, especially in Sub-Saharan Africa (SSA), are still out-of-school[1], the majority are now enrolled and attend school more often (United Nations, 2015). For the majority of these enrolled children however, very little actual learning occurs as they progress through grades (Pritchett & Beatty, 2012). This leads to an important global education policy question – how to ensure effective learning for every child that is enrolled in school? Although a number of studies addressing this question have been conducted in the recent past, there is very little evidence on the effectiveness of the curricula in East Africa[2] (Atuhurra, 2014; Twaweza, 2015a).

In this paper, we define curriculum as the prescribed content (knowledge, skills and competences) to be taught and learned, which provides the basis for assessment in form of tests (Twaweza, 2015b). It is clear from this definition, that the curriculum lies at the heart of the learning process and its' significance for children's learning achievements from early childhood through primary school is critical, mainly because ineffective learning in the early years hinders development of critical foundational skills that a child needs to succeed both in school and later in the world of work (UNESCO, 2014). An effective curriculum is realized through minimization of the gap (sometimes, gulf) between the officially stipulated syllabus content and what is delivered in the classroom, assessed through tests and exams, and learned (Muskin, 2015).

Since 2007, Uganda has implemented a thematic curriculum for the first three lower primary grades, whose main goal is to achieve quick development of foundational literacy, numeracy and

[1] About 57 million children of primary school going age are out-of-school worldwide, majority of whom live in Sub-Saharan Africa (United Nations, 2015).
[2] Areas that have been covered extensively in the recent past included teacher effort and performance, pupil peer effects, pedagogical practices, community involvement, class size effects, school choice, and pupil health statuses.

life skills. The content of the thematic curriculum is organized around themes of immediate meaning and relevance to the learner and is delivered in the child's local or familiar language (Altinyelken, 2010). Starting in grade four and through upper primary, the curriculum transitions from being theme-based to subject-based, and from using the child's familiar language to English as the medium of instruction[3]. Although the primary school curriculum advocates for a formative assessment approach that focuses on a learner-centered diagnosis and taking of remedial steps for effective learning during the normal course of teaching, the practical realities of large class sizes have meant that this is hardly done (Ezati, 2016). In practice, there is clearly overemphasis on high stakes summative assessments, typified by the end of primary school national examinations – the Primary Leaving Examinations (PLEs). A few recent studies of the thematic curriculum in Uganda have praised its' intentions, but also repeatedly highlighted its' lack of relevance to the contextual realities prevailing in schools and classrooms across the country, especially outside of the urban settings of major towns. In one of the early studies, Altinyelken (2010) sought to understand teacher perspectives of the thematic curriculum. The study found that the initial enthusiasm teachers had developed for the new curriculum quickly turned into frustration as they discovered that its' recommended pedagogical approaches were inappropriate and impractical in their settings. While analyzing the P3 and P6 children's performances in recent National Assessments of Progress in Education (NAPE), Najjumba & Marshall (2013) raise questions on some critical curriculum aspects including time allocation, content sequencing and pacing, thus suggesting a fundamental structural problem with the design versus delivery aspects of the thematic curriculum. A more recent review of the basic education curriculum reforms that have taken place in Uganda since 1962, finds that in essence, all the five major reforms did not achieve, in practical terms, any

[3] The primary school curriculum identifies three clear cycles: lower primary covering grades one to three, the transition grade four, and upper primary covering grades five to seven.

significant progress. Critical curriculum aspects such as scope of content covered, sequencing and alignment were never really addressed in any meaningful way (Ezati, 2016).

Early Childhood Development (ECD) relates to children's development of both cognitive and non-cognitive abilities in their early formative years, usually by age nine. A large body of cross-disciplinary studies have found evidence to the effect that even after adjusting for maternal education, ECD is still strongly associated with variations in children's basic learning skills, mainly relating to receptive vocabulary or language abilities and the development of executive functions of memory and attention. In most developing countries, household wealth remains a major determinant of both pre-school attendance and the child's observed development outcomes (World Bank, 2015). Between the ages of three and six years, children in Uganda are eligible to attend pre-primary school, a place where they experience the greater part of cognitive and other critical life skills' development. In pre-school, children are continuously guided and supported in discovering themselves and their environment through persistent stimulation and cultivation of such life-critical skills as control of own impulses, appreciation of other people's perspectives, focused attention, active listening, completion of assigned tasks and appropriate behavior. While conducting the annual household-based learning assessment for 2015, Twaweza found that only 27% of children in Uganda aged between three and five were attending pre-primary education, translating into a four percentage point improvement from 23% in 2011 (Uwezo, 2016) . This finding suggests, potentially that about 42% of children will be able to attend by 2030[4]. Large location and socioeconomic status-based disparities in attendance do exist however, with over a half (53%) of the 3-5 year-olds found to be attending in urban areas in 2011 while only 20% of the rural-based children were attending (Uganda Bureau of Statistics, 2012). With only 7% of children

[4] This is on the basis of an assumption of a common trend using two data points – 2011 and 2015.

from the lowest wealth quintile attending, and considering that the majority of the ECD centers in Uganda are privately owned[5] and not fee-free, the most prominent constraint hindering universal enrolment in pre-primary schools has a lot to do with the associated costs of attendance (UBOS, 2012; Wodon, Tsimpo & Onagoruwa, 2016). In his bestselling thesis on understanding success, Gladwell (2011) highlights opportunities (or the lack thereof) that accrue from early life and persist for years, thereby locking children into overall life achievement or underachievement. In Uganda, the few children that attend pre-schooling obtain a unique head start advantage that, cumulatively results into enormous returns in form of better learning achievements and overall long-term life outcomes.

In place since 2005, Uganda's pre-school curriculum is a needs-based learning framework designed to develop critical foundational skills for three to six-year-olds. By the time they complete the final year of pre-school, children are expected to be able to apply mathematical concepts in their day-to-day experiences and use appropriate English language to communicate with others. Children at this stage have developed 'number sense' and 'basic mathematics operation' competences so as to be able to recognize or create number patterns and represent or interpret information in pictorial form. Relating to language ability, they have developed phonics and phonemic awareness competences so as to be able to listen to and re-tell simple stories, use acquired vocabulary while playing, read simple stories, and write own stories about personally meaningful experiences (NCDC, 2005).

While the Government White Paper (1992) specifies broad aims and objectives of education to be achieved at each basic education level in Uganda, we have not found any evidence that suggests,

[5] About 80% of ECD centers are privately owned (MoGLSD, 2013).

until now, the existence of a systematic and comprehensive multidimensional content taxonomy for basic education in Uganda that specifies, for each broad learning area, the relevant topics, subtopics and cognitive demand (performance expectations) levels to be achieved in order to reach these broad education goals. This not only makes international comparisons difficult, which compromises the global competitiveness of Uganda's basic education, but also makes it extremely hard to objectively assess the scope, sequence, relevance and alignment of the content embedded in the curriculum at each cycle and grade level and how it fits in subsequent levels. In relation to pre-primary attendance and the contextual relevance of the thematic curriculum in Uganda, it seems quite important to generate policy-relevant evidence that explains how in-class instruction and learning, especially in very overcrowded lower primary grades, is affected by children's pre-school attendance status. As a first step to establishing this evidence, it is critical to objectively describe, preferably quantitatively, the content that is embedded in the national curriculum standards and assessments, and then to establish their alignment with the actual teaching and learning that takes place in schools (Porter, 2002; Smithson, 2016).

In this study, we describe content progression as prescribed in the national curriculum standards, analyze the content embedded in the end-of-cycle national assessments[6], and establish alignment between standards, assessments and classroom instruction – for primary mathematics in Uganda. To achieve this, we composed a three-member curriculum expert team for primary mathematics, who were trained on the Surveys of Enacted Curriculum (SEC) methodology. Using the expert-generated topic and sub-topic level datasets arising from coding and rating each learner competence in the primary mathematics content standards, and coding and rating each assessment

[6] We analyze the assessment items in the national exams (Primary Leaving Examinations – PLE) for the years 2013-2015.

item in the end-of-primary mathematics national exams, we conducted detailed descriptive analyses that portray relative emphasis areas of the curriculum and national assessments in Uganda. Furthermore, we analyzed similar datasets arising from the survey of a sample of in-service teachers' instructional content as delivered in the classroom. We report indicator measures that summarize detailed quantitative relationships representing comparisons of two-dimensional arrays of content descriptions that generate alignment characteristics between any two specified categories.

We find that three major topics form the main focus of the mathematics curriculum strand in all the seven primary grades, 'number sense', 'operations', and 'measurement'. While the topical focus is more nuanced in the upper primary grades (P4 to P7), these three topics are almost exclusively the only ones intended for coverage in lower primary grades (P1 to P3). Throughout primary school, the curriculum standards place most emphasis on the development of competences targeted at computational proficiency and conceptual understanding of mathematical ideas. The lower-order performance expectations of "reciting", "memorizing" and "recalling" mathematical facts receive very minimal emphasis in the syllabuses for lower primary grades. The curriculum standards prescribe the topic 'measurement' to be targeted at developing children's abilities to solve non-routine real-life mathematical problems.

Regarding alignment of curriculum standards with the national-level standardized assessments, we find that the assessments disproportionately emphasize one topic 'measurement', receiving about 35% coverage in the PLEs as compared to the standards (about 15%). For this topic, both the standards and the exams emphasize development of ability to 'apply to novel situations'. For the two topics, 'Number sense' and 'Operations' the curriculum standards emphasize development of both 'Perform' and 'Demonstrate' abilities, whereas the PLEs predominantly emphasize 'Perform Procedures'.

On the disparities in classroom content delivery, we find that rural-based teachers in lower primary differ in their emphasis and focus from their urban-based counterparts. While both sets of teachers emphasize the same three major topics as noted above, 'measurement' is the least emphasized of the three by rural teachers and yet the most emphasized topic by urban teachers. Furthermore, urban teachers prioritize more the development of children's ability to communicate and demonstrate understanding of the mathematical ideas behind the concepts they are teaching. On the contrary, rural teachers focus more on developing children's recall, recite and memorize abilities.

Put together, our findings from analyses of the primary mathematics curriculum in Uganda, suggest that there are particular topics that are of great consequence to children's learning and these need to be mastered from early on. The end-of-primary cycle national assessments seem to disproportionately favor urban-based children partly because the teachers in rural settings seem to lack competences and facilities to deliver effectively the teaching of mathematics topics/subtopics and targeting of cognitive demand levels that dominate these assessments. Clearly, rurally-based children get comparatively less opportunities to learn the content in a manner that would develop the required knowledge and abilities to excel in these exams.

The rest of this paper is organized as follows. The contextual background to basic education in Uganda and a description of the basic education curriculum in Uganda are given in section 2. Section 3 makes a case for and explains the SEC methodology relative to this study. We present our findings in section 4, followed by a detailed discussion of our findings, their implications for Uganda's education policy and some recommendations in section 5. Section 6 concludes.

2.0 Contextual background

While presenting for public debate the official Government of Uganda (GoU) position on the proposals made in the Education Policy Review Commission (EPRC) report, in what has famously become known as the 1992 Government White Paper (GWP), then minister for education and sports clearly articulated the aspiration of Uganda's education system: "Uganda must henceforth seek to establish the highest quality of education possible as the basis for fundamental change, revolution and national development" (Government of Uganda, 1992). Twenty-six years later since that visionary statement, education policy makers in Uganda, and generally in most of the developing countries of Sub-Saharan Africa (SSA) are still puzzled about how to achieve this vision. We start by defining basic education in the Ugandan context, describing its' recent history and identifying its' challenges, and then dwell on the concept of curriculum mainly at primary school level**.**

2.1 Uganda's basic education

The GoU defines basic education as *"the minimum education package of learning made available to each individual or citizen through phases of formal primary education and non-formal education system(s) to enable him or her be(come) a good and useful person in society"* (GoU, 2008). Put differently, basic education lays the foundation or the "infrastructure" within which reading, writing and numeracy skills that are needed for further learning are developed (Ezati, 2016). Basic education in Uganda constitutes the first 12 years of formal schooling with three levels, pre-primary for at least one year, primary for seven years and lower secondary for four years. Pre-primary schooling is recognized as the first level of education in Uganda, targeting children aged between three and five years. Predominantly, pre-primary education takes place in ECD centers, over eighty percent of which are privately owned (Ejuu, 2012; MoGLSD, 2013), and is therefore not tuition-free. A nationally recognized learning framework that prescribes content to be learned by three-to-six year old children attending the ECD centers has been in existence since 2005. Recent evidence from Twaweza's Uwezo household-based annual learning assessments however, indicate that only about 27% of 3-5 year old children in Uganda are attending pre-primary education (Uwezo, 2016). At age six children are required to enroll into primary school, which lasts for seven years and has three distinct learning cycles – lower primary grades one to three, transition grade four and upper primary grades five to seven. Since 1997, the GoU has been running a universal tuition-free primary schooling model. However, a significant minority of about 20% of the primary school children in Uganda attend for-fee private primary schooling (MoESTS, 2014). At the end of the seventh grade, children sit for a high-stakes national examination that determines entry into lower secondary school.

Uganda's formal education system is entwined with the introduction of Christianity by white missionaries in 1877 (Ssekamwa, 1997). With time however, some aspects of the education system have progressively been changing in response to the prevailing development challenges, while others have remained and continue to puzzle policy makers. Post-independence, several reforms of Uganda's education were undertaken mainly aimed at addressing a number of gaps. During the colonial times, the Phelps-Stoke commission of 1924/25 was the first of four commissions appointed to review and propose recommendations on various aspects of Uganda's education. Immediately after gaining independence, the GoU set up the Castle commission in 1963 and tasked it to undertake a comprehensive review of the education system. The Education Policy Review Commission (EPRC) was set up in 1987 and tasked to inquire into the policies governing education in Uganda (GoU, 1992). In its' 1989 report, the EPRC criticized the existing education system's inability to relate educational activities to the community and the people, thus promoting an ‘exclusively literary’ or elitist education model (Ssekamwa, 1997; Ezati, 2016). One common theme kept appearing in all the proposals of the three commissions, that is, the need to integrate practical and vocational skills into the primary and secondary education curricula so as to ensure graduating students were more productive and would meet the existing labor demands. One of the most important proposals made by the EPRC was to require that GoU abolishes the mandatory payment of tuition fees as a pre-condition for access to primary schooling. The GoU consequently introduced the Universal Primary Education (UPE) policy in 1997, which led to immediate dramatic increases in enrolment and attendance, culminating into extremely overcrowded classes, especially in the lower primary grades (Deininger, 2003).

Whereas access to primary education has significantly increased and the education sector is now allocated a significant proportion of the national budget resources, the extremely low quality of learning taking place in Ugandan classrooms today presents a real threat to the country’s future development prospects. Several studies have been conducted in the recent past, showing that even within the East and Southern African region, the performance achievements of Ugandan children and their teachers are significantly lower than those of other countries, including Kenya and Tanzania (Byamugisha & Ssenabulya, 2005; Ward. M, et.al. 2006; Lucas. M. Adrienne, et.al. 2013; USAID/RTI, 2014; Jones, 2015; Rose Pauline & Alcott Benjamin, 2015; Atuhurra, 2016; & Uwezo, 2016). With low learning outcomes being strongly linked to incidences of early dropout from school, it is little wonder primary school enrollment figures are currently stagnating, survival to the last grade is a measly 32%, and Uganda currently lags in the fourth from bottom position on school completion in SSA (GPE, 2015). In their highly influential study of children’s learning profiles in South Asia and Africa, Pritchett and Beatty (2012) find that even after several years of instruction in school the majority of children are still devoid of foundational skills of counting, reading and writing. They explain this shocking result as arising from overambitious curricula that make it impossible, from early on, for children to keep pace. To this end, this study builds on Pritchett and Beatty (2012) by analyzing, for primary mathematics in Uganda, critical curriculum effectiveness aspects including scope, progression or sequence, alignment and the rural-urban instructional content divide.

2.2 The Primary school curriculum

We define curriculum as the prescribed content to be taught and learned, which provides the basis for assessment in form of tests (Twaweza, 2015b). Consistent with this definition, Porter (2004) characterized the curriculum into four types - the intended or prescribed, the enacted or taught, the assessed, and the learned curricula. The Intended curriculum refers to the one that is prescribed in the content standards, which states what learners must know and be able to do at a particular point in time. The enacted curriculum is what the teacher delivers and how he or she delivers the content to learners in a learning environment. The assessed curriculum refers to the content on which students are examined or tested to establish learned competences. Finally, the learned curriculum is what the learner knows and is able to do in a given class/grade level. To understand the relationships between these four types of curriculum we start with the intended which provides the instructional target for what is actually taught. The taught or enacted curriculum is the best predictor of students' achievement levels in tests. From these achievement scores that children obtain on the tests we are able to determine the learned curriculum. The content of these tests represent the assessed curriculum. In a standards-based system, the alignment between these four types is of utmost importance since it forms the basis for assessing curricula effectiveness (Case et al., 2004; Porter, 2004; Smithson J, 2013).

In a detailed review of the recent history of curriculum reforms in Uganda, Ezati (2016) identifies five primary curriculum reform documents – 1965, 1967, 1990, 1999 and 2007-2010. The author notes that in all the five reform documents, only minimal changes were made on critical curriculum aspects – scope, sequence, relevance and language of instruction. Although the number of subjects covered in primary reduced from the 12 reflected in the 1967 curriculum to the 9 reflected in the 2007-2010 curriculum, Ezati (2016) notes that these changes were mostly cosmetic, characterized by repackaging and merging of the same content, thematic formatting and subject re-contextualization. The current primary curriculum is organized in three distinct cycles – the lower primary theme-based curriculum for P1–P3[7], the transition to subject-based P4 curriculum, and the upper primary subject-based curriculum for P5-P7 (NCDC, 2006a; NCDC, 2006b). In previous years, a number of studies had described the primary school curriculum in Uganda as too theoretical, pays scant attention to the development of competencies and skills, generally out of date, overloaded and not learner-centred (Ssekamwa, 1997; Najjumba & Marshall, 2013; Ezati, 2016). In most of these studies, the measures used to assess curriculum overload included the number of subjects, volume of content, teaching time and the precision of the guiding notes to teachers (APPA, 2014). The thematic curriculum, introduced since 2007, is competence-based, adopts a learner-centered approach to teaching and assessment, reduced the number of subjects from twelve to nine, organized the learner content into themes of immediate meaning and relevance to the learner and produced accompanying teacher guides and resource books for lower primary. A field investigation of the actual implementation of the thematic curriculum however, found that teachers were struggling to actualize it and had grown frustrated by its'

[7] The content of the thematic curriculum is organized into twelve themes - our school, our home, our community, the human body and health, weather, accidents and safety, living together, food and nutrition, transport, things we make, our environment, and peace and security.

inappropriateness to the actual situation they faced in the classroom (Altinyelken, 2010). Some of the mentioned challenges that teachers highlighted included insufficient time to cover the prescribed content, controversies arising from the lack of a widely accepted local language to be used as the medium of instruction in some areas, overcrowded classrooms that made group work difficult, lack of knowledge about how to practically conduct continuous assessment for each child, and lack of teaching and learning aids. Pritchett and Beatty (2012) highlight a major consequence of such overambitious curricula in developing countries of South Asia and Africa, as the shockingly flat learning profiles seen even after children have undergone several years of instruction.

3.0 Methodology: Surveys of Enacted Curriculum

Li and Sireci (2005)'s detailed review of curriculum alignment studies identified five most prominently used models for curriculum analysis - the Webb model (1997), the La Marca model (2001), the Achieve model (2001), the Surveys of Enacted Curriculum (SEC) model (2002) and the Council of Basic Education (CBE) model (2002). While the other four models are categorized as high complexity models due to the relatively high number of criteria they employ in their analyses, the SEC model is considered a moderate complexity model which uses mainly two criteria, content topics and cognitive demand[8]. Moreover, the SEC model extends Bloom's concept of the taxonomy table (Krathwohl, 2002) for curriculum alignment analysis to an explicit three-dimensional concise articulation – representing not only the intersection of subject matter content and cognitive process categories, but also the relative emphasis or importance attached to each

[8] Whereas the content topics/sub-topics relate to what the student needs to know, the cognitive demands are specific descriptions of performance expectations for each learning objective or competence to be achieved, i.e. what students should be able to do (Smithson, 2015). Five categories of student performance expectations (cognitive demand) are employed by the SEC model: **B** – Memorization or Recall; **C** – Perform Procedures; **D** – Demonstrate understanding; **E** – Analysis, conjecture and proof; and **F** – Synthesis, integration and novel thinking.

combination of these two components – of intended learning objectives, assessment items and classroom instructional experiences. Both the expert-based activities of judging the content embedded in the standards and assessments, and the detailed analyses of the data can be collected, processed and reported using a simple Microsoft Excel spreadsheet application provided by the Wisconsin Center for Education Research where the SEC system is housed. Li and Sireci (2005) highlight that the SEC model has been widely used to produce alignment analyses between standards, assessments and instruction across the United States, leading to school improvements and improved student success. States keep coming into and going out of the SEC collaborative according to need. In Africa, the SEC approach is being used to improve instruction in STEM middle schools in Egypt.

Utilizing a common two-dimension content matrix that allows analytical comparisons across teachers, schools, districts and states, the SEC represents a robust, valid and reliable framework providing research-based data collection, analysis and reporting tools for describing all four aspects of the curriculum referenced above, i.e. the intended, enacted, assessed and learned curriculum (Porter, 2002; Case B. et al., 2004; Smithson, 2017). In other studies, the SEC approach has been described as the most predictive model of student achievement scores, and the only model that provides alignment indices at the taught or enacted curriculum level (Case & Jorgensen, 2004). For the purposes of this study in which we analyze the prescribed primary mathematics content progression, the alignment between standards, assessments and classroom instruction, and the rural-urban classroom instruction quality divide, the SEC provides a clear and concise articulation.

The SEC model presupposes the existence of a comprehensive multidimensional subject-specific taxonomy for each of the subjects or learning areas to be analyzed. Each taxonomy systematically lists content in the form of topics and sub-topics, in combination with five cognitive demand categories for describing instruction at each grade. Such a taxonomy forms the base reference document for coding topics/subtopics, and rating cognitive demand levels that are embedded in the curriculum documents, assessment items and classroom content under review. For each subject or learning area, the review is undertaken by a team of three or more highly experienced and well trained individuals who are expertly knowledgeable in the subject matter. Each member of the expert team works independently, applying their expert judgment to make a call that they record in the two-dimension content matrix of topic/subtopic and cognitive demand level for each competence or learning objective. This call is in form of a descriptive topic/sub-topic number code combined with a letter code that identifies the relevant cognitive demand level.

The SEC model identifies five levels of cognitive demand or expectations for student performance[9] - memorize or recall; perform procedures; generate or demonstrate conceptual understanding; analyze, conjecture, prove or hypothesize; and synthesize, make connections, integrate, apply concepts or solve non-routine problems (Smithson, 2015). After completion of their individual-level independent reviews, subject team discussions are held in which each expert on the team has a chance to discuss their rationale for selecting one or another descriptor for any given competence or assessment item. Whereas there is no requirement for a team consensus, experts may change their descriptions if they are convinced that their original selection may not have been appropriate for the specific learning objective. A two-step data analysis process is then used to arrive at the final description of the curriculum being analyzed. First, the results of each analyst are processed into proportional results, so that the total across all of the analyst's descriptive entries (or 'codes') will sum to 1.00. That is, each analyst's description is reported in terms of the relative emphasis

[9] The detailed descriptions of each of the five cognitive demand levels are reflected in the cognitive demand matrices for Mathematics – Annex A1.

each analyst assigned to the various topics and performance expectations included in their description. Once the results for each analyst have been normalized in this way, the final description is obtained by averaging the results across all analysts. The final results thus report the relative emphasis of content embedded in the described document as described by the analysis team of experts.

Two levels of SEC analysis are possible, coarse grain and fine grain analysis. Coarse grain analyses are summative or evaluative analyses that portray relative emphasis on topics and cognitive demand. Such analyses are useful for giving a general overview of the distribution of content across topics and performance expectations. On the other hand, fine grain analyses are formative diagnostic analyses at the more micro subtopic level. After obtaining the summative alignment picture, the fine grain maps are used to point to specific subtopic areas that need to be addressed in order to improve alignment (Smithson, 2013). Three-dimensional content maps that visually display informative descriptions of the content embedded in the curriculum documents constitute the main output of SEC analyses (Smithson, 2015). The three axes represent topics or subtopics on the Y-axis, performance expectations or cognitive demands on the X-axis, and contour lines and color bands depicting the level of emphasis on the Z-axis. Two more outputs are available from the SEC analysis. First, an alignment analysis summary table reporting the overall alignment index (OAI) and its' constituent three marginal alignment indices - topic coverage (TC), cognitive complexity (CC) and balance of representation (BR). The OAI, TC, CC and overall BR measures are interpreted based on the recommended SEC threshold of 0.5 within the range from zero to one. Zero represents a condition of no alignment or perfect misalignment, and one refers to a situation of perfect alignment. These topic-level measures are reported on the same 0 to 1 scale with the exception of the topic level BR measures which report the simple difference of relative emphasis reported across the two descriptions being aligned. Thus on the topic level BR scale, perfect balance would be indicated by a measure of 0.00 (Smithson; 2015). Second, the marginal charts that make it easy to assess relative emphasis on a two-dimensional display across topics/subtopic and cognitive demand.

3.1 How was SEC contextualized in Uganda?

Twaweza, a civil society organization, works on enabling children to learn, citizens to exercise agency and governments to be more open and responsive in Tanzania, Kenya and Uganda (Twaweza, 2015(a)). Twaweza adopted the SEC approach to its work of analyzing the effectiveness of the basic education curricula in all the three countries of East Africa. In each of the three countries, in the fourth quarter of 2015, Twaweza conducted consultative forums at which the concept of curriculum effectiveness was discussed, and soon led to the composition of panels of curriculum experts for each country. In Uganda, the panel of eleven experts were drawn from two national universities, the national curriculum body, primary teacher colleges, schools and the school inspectorate department of the education ministry[10]. The members of the panel of experts were oriented and trained on the SEC, with the Wisconsin Center for Educational Research (WCER) directly training the country team leads who in turn trained the other members of the panel. The experts were then organized into four core subject teams - mathematics with three experts, English with two experts, Science with three experts, and Social studies with three experts. Whereas SEC recommends a minimum of three experts per subject, we were financially constrained to add an extra expert to ensure the English team met this minimum requirement.

[10] The detailed composition in Uganda's case was as follows: three experts from the National Curriculum Development Centre (NCDC), one expert from Makerere University's school of education, one expert from Kyambogo university's teacher education department, one expert from the ministry's directorate for school inspections, two primary school teachers, one expert from Nakaseke core primary teachers' college and two experts from Twaweza East Africa.

The primary school curriculum in Uganda is organized in three distinct cycles- the thematic curriculum for lower primary grades one to three, the transition subject-based grade four curriculum, and the upper primary subject-based curriculum for grades five to seven. There are four core subjects assessed at the end of the seven-year primary cycle. The discussion in this paper focuses on the analysis of and findings from only one core subject – primary mathematics.

Since our best efforts to locate an existing subject-specific taxonomy proved unsuccessful for all the four core subjects, the subject expert teams were tasked to review and adapt the USA's K12 subject taxonomies to fit the Ugandan context. During this contextualization process, a number of topics and subtopics appearing on the K12 taxonomy were dropped and very few (if any) added. Because of the highly context-specific nature of the taxonomy for Social Studies, the K12 taxonomy was basically used as a mere guide to developing a completely new Social Studies taxonomy for Uganda. These now contextualized taxonomies were adopted and thus formed the basis for the task of coding and rating that the experts embarked on[11]. The contextualized taxonomy for mathematics has thirteen topics - number sense, operations, measurement, consumer applications, basic algebra, advanced algebra, geometric concepts, advanced geometry, data displays, statistics, probability, analysis, and special topics[12].

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[11] The contextualized taxonomy for mathematics is shown in annex A2.

[12] The contextualized taxonomy for integrated science has sixteen topics - cross-cutting themes; science and technology; science, health and environment; measurement and calculation in science; components of living systems; botany; animal biology; human biology; reproduction and development; ecology; energy; motion and forces; electricity; properties of matter; earth systems; meteorology; and fresh water science.

The taxonomy for Social studies on the other hand, has twenty five topics - social studies skills; human culture; technological change; multicultural diversity; social problems; foundations of government; principles of democracy; constitutionalism; political and civic engagement; managing resources; how markets work; economic systems; economic interdependence or globalization; personal finance; map skills; places and regions; physical geography; human and cultural geography; human and environmental interactions; agricultural practices in East Africa; People of East Africa; History of Africa (people, events and documents); foreign influence in Africa; nationalism and the road to independence; and nature of vegetation.

The contextualized taxonomy for English language at primary has eighteen topics - phonemic awareness, phonics, vocabulary, text and print features, fluency, comprehension, critical reasoning, author's craft, writing processes, Consistent with the recommended SEC procedures, each panelist reviewed the content in the curriculum standards and national assessments individually and selected the most appropriate code(s) and cognitive demand levels for each competence and assessment item. Subject team discussions were then held, at which the experts justified their coding and rating, and made independent individual decisions on whether or not to alter their original calls. For each of the four core subjects taught and examined at primary school level, the coding was done for each competence listed in the curriculum standards for all the seven grades, and for the end of primary cycle national examinations for the three years 2013, 2014 and 2015. For content that may well be explained across several topics and/or with varying cognitive demand levels, experts could enter up to six combinations for competences in the curriculum standards, and up to three combinations for question items in the primary leaving examinations[13] (PLEs).

3.2 Pilot survey of classroom instruction

Considering performance in both the citizen-led 'Uwezo' and end-of-primary cycle national assessments, and the rural/urban composition of primary schools in Uganda, two districts were purposively selected for the piloting of the teacher survey in September 2016 – 'Wakiso' in central region representing a highly urbanized and consistently top-rated district, and 'Iganga' in Eastern region being more rural and lowly performing. Real budgetary constraints for this activity in Uganda meant that only public schools were selected and teachers from only three of the seven primary school grades participated – primary three, five and six.

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elements of presentation, writing applications, language study, listening and viewing, speaking and presenting, forms of text, genre, sources of text, and choice.

[13] See Annex A3 for an example of the two-dimensional matrix of topic/subtopic codes and levels of cognitive demand used as part of this paper's analyses.

Considering the rural/urban and geographical location status of each school, the probability proportional to size sampling technique was used to randomly select schools – 100 schools from each of the two districts. Within their school location categories, selected schools were randomly assigned to one of two frames – frame 1 consisted of P3 English teacher, P5 Math teacher and P6 SST teacher; frame 2 comprised of P3 Math teacher, P5 English teacher and P6 Science teacher. Each selected school belonged to only one of the two frames. This sampling design would generate six hundred primary school teachers (200 Math, 200 English, 100 SST and 100 Science), three from each school and three hundred from each district. Working through the existing core Primary Teacher College (PTC) and Coordinating Centre (CC) structures, the selected teachers were identified and invited to the respective core PTC – Bishop Willis core PTC for Iganga teachers, and Shimoni core PTC for Wakiso teachers. Over two days, the teachers were oriented on the SEC approach, including hands-on practice sessions, before being asked to individually complete the survey tools responding to questions on their instructional content and practices for the specific class-subject combination they had been originally selected. The instructional content part of the survey covered three major areas – topics and subtopics covered, time spent on each topic and subtopic, and the relative emphasis put on each learner performance expectation. On the other hand, the instructional practices part included questions on the school and classroom environment, instructional activities and influences, classroom instructional readiness, teacher opinions and beliefs, professional development activities, and other basic teacher characteristics – gender, experience, education and qualification.

4.0 Findings

As was explained in section 2.2, the content for the lower primary grades is organized into 12 themes that offer immediate interest/meaning and relevance to the learner, and is delivered in a local or familiar language. The goal at this level is to develop basic competencies in literacy, numeracy and other life skills. Designed mainly as a transition year, grade four children are transitioned from a theme to a subject-based curriculum with a steady change from local to English as the language of instruction. The content for upper primary grades five to seven are fully arranged in subjects, and the main focus is toward laying a strong foundation for secondary education or readying the learner for the world of work after primary school completion (NCDC, 2006a).

In this section, we present findings from the analyses of the primary curriculum standards, the national assessments, and the teacher responses from the pilot survey of teachers' instructional content from the two districts of Wakiso (mostly urban) and Iganga (mostly rural). These findings touch on curricular scope and sequence, alignment, and location-based classroom instructional variations. They paint a descriptive picture of the content that is embedded in the standards and national assessments, and highlight the differences in classroom instructional emphases between rural and urban schools. This study represents the very first time the SEC framework has been used to analyze curriculum alignment in Uganda. We expect that findings from these analyses will go a long way to inform and likely influence future review and reform initiatives of the basic education curriculum in Uganda. We present first, the findings from the content progression analysis, then the alignment analyses, and conclude with the location-based differences in instructional content delivery. Since this paper presents the findings for only one core learning area – primary school mathematics – we postpone the discussion on between-subject cross-cutting narrations to future work.

4.1 Primary mathematics content progression analysis

We use content analysis maps at both topic (coarse grain) and sub-topic (fine grain) levels, and relative emphasis charts to depict the summative picture of the content in the curriculum standards. The content maps represent a three-dimensional topographical display of topics or sub-topics on the vertical axes, the five levels of learner performance expectations on the horizontal axes, and the relative emphasis for each intersection of topic or sub-topic and performance expectation as the third dimension (z–axis) represented by contour lines and variations in color schemes. The specific data points can be found at the intersection of the topic/subtopic and cognitive demand level.

Figure 1(a) presents the topic-level coarse grain maps for mathematics content – the first panel for the lower primary grades (P1 to P3), the second panel for the transition class (grade four), and the third panel for the upper grades (P5 to P7). In all the three panels, three topics dominate overall emphasis – number sense, properties and relationships; operations; and measurement. This is reflected through analyzing the intersection points with the highest peak (emphasis) in the three-dimensional contour maps. On the two-dimensional marginal charts in figure 1(b), this overall topical emphasis structure can be clearly seen – over sixty percent of the emphasis on topic coverage for each of the three panels is devoted to these three topics.

Looked at together, figure 1(a) and figure 1(c) reveal the main emphasis structure on student performance expectations, the cognitive demand levels. Throughout the seven grades the standards emphasize developing learners' abilities to perform mathematical procedures and demonstrate understanding of mathematical concepts. For one particular topic, 'measurement', the cognitive demand structure throughout all the grades is intended to emphasize development of children's abilities to make connections and apply mathematics to real world situations by solving non-routine problems. Figure 1(d) shows a more diagnostic fine grain level analysis of the intended emphasis structure for all the subtopics within the topic 'measurement' across the grades as the child progresses.

While the topical coverage in the transition class and the upper primary grades is more broadened, the focus in the lower primary grades is almost entirely intended to be on the three dominant topics emphasized above. Clearly, from the third panel in figure 1(b), the complexity in terms of topic (and their respective underlying sub-topics) coverage is greater in the upper primary grades.

4.2 Alignment between standards, assessments and instruction

In this section, we first analyze alignment of the upper primary curriculum standards with the national assessments (aggregated for the years 2013-2015) done at end of the primary cycle – the Primary Leaving Examinations (PLEs). We also analyze the alignment between the curriculum standards and classroom instruction for the two grades – three and five – for which we have teacher instructional content survey data. We use content maps, relative emphasis charts and alignment tables to present and explain the findings.

Figure 2(a) and 2(b) depict the alignment structure between the content embedded in the upper primary mathematics curriculum standards and the PLEs for the three years 2013-2015. While it is clear that the exams cover the whole breadth of the topics prescribed in the curriculum standards, the three key topics – number sense, operations and measurement – are equally as dominant in the examinations. However, one particular topic – measurement – is always mostly emphasized in the national examinations, and disproportionately so when you compare with its' intended relative emphasis level in the curriculum standards. In terms of emphasis on cognitive demand, the PLEs similarly exert most emphasis on ability to perform mathematical procedures, demonstrate understanding of concepts, and solve non-routine problems. For the two topics, number sense and operations, the curriculum standards emphasize development of children's abilities to perform procedures and demonstration of conceptual understanding while the national examinations predominantly emphasize 'perform procedures'. As shown in the alignment table (table 1), a low overall alignment index (OAI) of 0.33 between the primary standards and the national assessments indicates the low levels of agreement between these two curriculum components. Similarly, our analyses of the pilot teacher survey data reveals low OAIs of 0.38 and 0.30 between the standards and classroom instruction for grade three and five respectively (results not shown).

4.3 Analysis of Rural-Urban instructional variations

In this section, we discuss the instructional content coverages of grade three and grade five mathematics teachers from a top-ranked highly urbanized district (Wakiso) as compared to those from a persistently low-ranked highly rural district (Iganga). Figure 3(a) shows that while rural-based teachers place most emphasis on 'number sense', their urban counterparts emphasized mostly 'measurement'. Similarly, while the cognitive demand emphasis structure favored by rural teachers is 'recall', then 'perform' and lastly 'demonstrate', the reverse is true for urban teachers. Both sets of teachers placed relatively less emphasis on the development of abilities to analyze/conjecture and to solve non-routine problems. As shown in figure 3(b), at the fine-grain diagnostic analysis level, subtopics such as 'use of measuring instruments', 'circles', 'time and temperature', 'capacity', and 'distance' received notably lower emphasis in rural schools. As shown in figure 3(c), the emphasis structure on instructional content by both sets of grade five teachers in rural Iganga and urban Wakiso is more similar. Although Wakiso teachers reflect a more balanced emphasis on the three key topics than Iganga teachers who emphasize more 'Number sense' and 'operations' than 'measurement', both sets of teachers prioritize the development of children's abilities to 'perform procedures' closely followed by 'recall' and 'demonstrate'. Again, 'analysis/conjecture' and 'solving non-routine problems' attract the least emphasis in both districts.

5.0 Discussion of findings, policy implications and recommendations

Given the critical foundational roles played by cognitive and other life skills-enhancing interventions in early childhood, it is obvious that the basic education curriculum represents the most important early education policy instrument for the achievement of individual, community and national development aspirations in Uganda. This study was motivated by four critical facts about basic education in Uganda. First, a very small minority of three-to-five year old children attend pre-primary schooling, more than seventy percent go straight from home to grade one at the nearest public primary school when aged six. Second, the majority of primary school-going children in Uganda fail to acquire basic learning competences of reading and counting even after several years of attendance, only until grade five do we see at least half of the children attain full competence at grade two level (Uwezo, 2016). Third, the end-of-cycle national Primary Leaving Examinations are of extremely high-stakes nature since they are used for selection for further education. Every year, a significant number of children who have endured at least seven years of primary schooling are rendered academic and life failures mainly because they are unable to pass these exams and henceforth live extremely precarious low-quality lives. Fourth, and strongly related to the third point above, the most disadvantaged children are by far the ones who come from low social status households and are mostly located in rural settings and attending rural primary schools. In this study, we utilized the SEC model to describe the content that is embedded in the curriculum standards, the national assessments and the classroom content delivered by grade three and grade five teachers from two distinctly different districts – one highly urbanized and the other rurally based. We summarize and discuss three main findings from this study.

From early in the study, it became clear that whereas curriculum standards that prescribe content to be taught in pre-primary, primary and lower secondary schools exist, the country lacks well-thought comprehensive subject-specific taxonomies for each of the learning areas covered under basic education in Uganda. To achieve the broad subject-level basic education goals, a carefully crafted articulation of the curriculum would systematically list the topics, sub-topics and performance expectations to be covered in each learning cycle and or grade level. This multidimensional specification of content coverage is required in order to attain planned sequential progress on content, ensure fit across grades and cycles, and eliminate any potential gaps and duplications along the way. Evidence of a non-systematic approach to content coverage across grades is evident in the analyses we have done. Based on our experience and for purposes of making a more efficient use of the SEC model to improve curriculum alignment in East Africa, we would strongly recommend that a comprehensive review of the K12 subject taxonomies be undertaken with a view to come up with nationally agreed subject taxonomies covering the 12 years of basic universal education for each learning area. Second, we would recommend that subject expert teams be composed with each team having at least four members to facilitate a more nuanced discussion and increase inter-rater reliability levels. The subject team members ought to meet the requirement for broad representation and yet possess the relevant breadth and depth of subject knowledge and experience which is critical when appreciating the bigger conceptual issues around content.

The second major finding from this study highlights alignment inconsistencies between the prescribed curriculum standards and the end-of-cycle national examinations. Two main aspects stand out here – the disproportionate predominance of a single topic in the national examinations, and the disparity in targeted learner performance expectations. While ‘measurement’ is one of the three most emphasized topics in the curriculum standards, it only covers about fifteen percent of the prescribed time on topic throughout the primary cycle. In the national examinations, however, this topic receives about thirty-five percent coverage. The second major alignment concern between the standards and the national assessments relates to the leaner performance expectations. While the standards emphasize, especially for the other two key topics, the development of children’s competencies to both perform mathematical procedures and demonstrate understanding the mathematical concepts, the national assessments are predominantly targeted at performing mathematical procedures. Such disparity can potentially lead to teachers focusing their instruction at developing rote learning abilities that might leave the children devoid of real understanding and make it hard to apply the knowledge gained to different contexts. The proposed subject-expert teams above, could play an important role towards achieving improved alignment between national curriculum standards and the standardized national assessments. Future surveys involving teachers across all the seven primary school grades will provide a more accurate picture of the alignment relationship between classroom instruction and national assessments.

The third major finding is in relation to the quality of mathematics instruction in rural as opposed to urban settings. While the findings of our study are valid only for the two districts we surveyed and the two classes (P3 and P5) for whom mathematics teachers' classroom instructional content was analyzed, the likelihood that our findings might hold nationally in not that remote. We find that lower primary teachers in rural areas, for reasons not yet clear in this study, fail to emphasize topics/subtopics that are of great consequence in later grades and dominate the end of primary school national examinations. Furthermore, competences that are mostly developed through practical application, such as 'use of measuring instruments' are less emphasized. This puts the children to a great disadvantage and may increase the likelihood of children dropping out early from school. Similarly, it is the rural-based teachers who less emphasize the need to develop children's abilities to demonstrate understanding of the mathematical concepts. The conduct of regular nationally representative surveys of teachers' instruction delivery would go a long way in bringing to the fore such important location-based instructional disparities, and thus greatly influence teacher recruitment, education, deployment, and development policies and interventions.

6.0 Conclusion

In this study, we have conducted a detailed analysis and given a clear description of the prescribed content of the mathematics primary curriculum in Uganda, the emphasis structure of recent national standardized mathematics assessments, and the variations in classroom instruction quality between mathematics teachers in rural and urban school settings in Uganda – using findings from our pilot survey of teacher instructional practices and content in Iganga and Wakiso districts. We adapted and applied the SEC approach to the Ugandan context for the first time, and unearthed concrete evidence that can be used to inform future curriculum policy decisions in the East African region and Uganda in particular. Even more importantly, the SEC tools provide a means for facilitating teacher-level reflection on their instruction individually and in groups, a prospect that holds real potential for sustainably improving the quality of instruction in the classroom while simultaneously achieving greater alignment with the curriculum standards. Future research should generate and analyze nationally-representative data on classroom instruction and assess subsequent impacts on teacher quality and children's learning achievements.

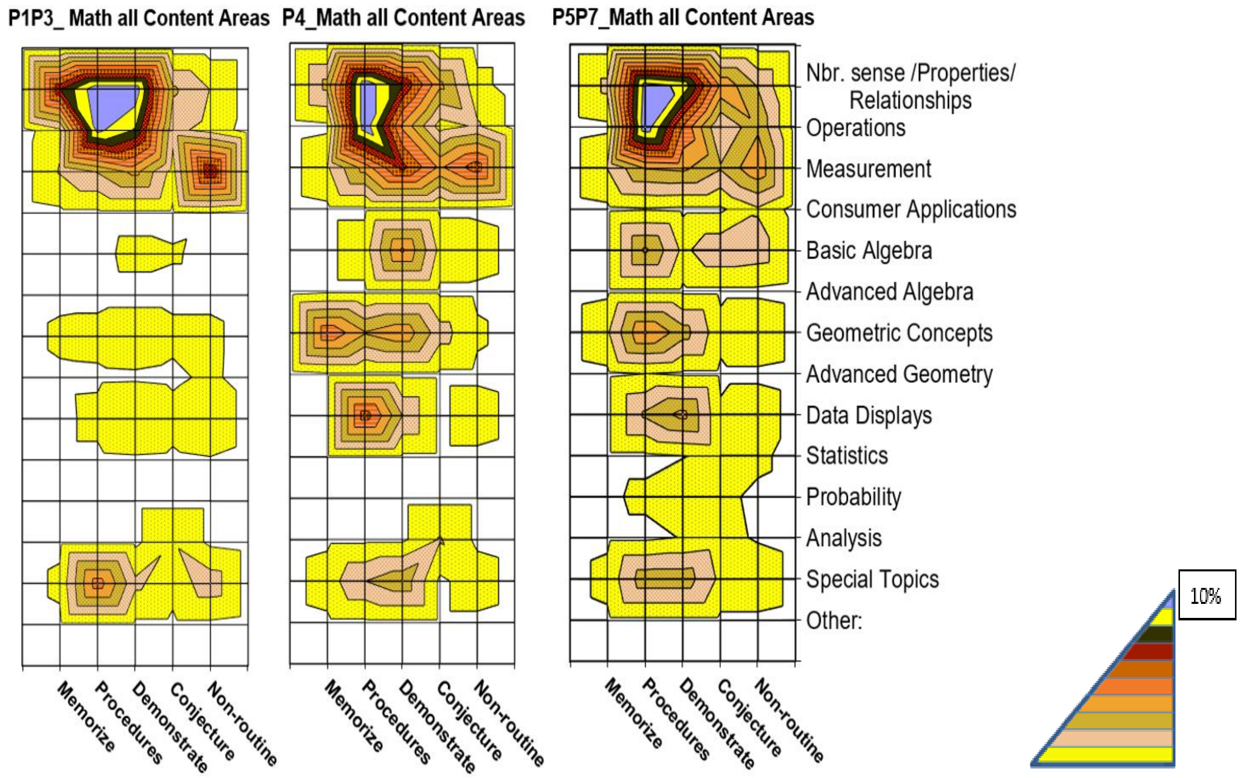

Figure 1(a): Mathematics curriculum standards – lower, transition and upper primary

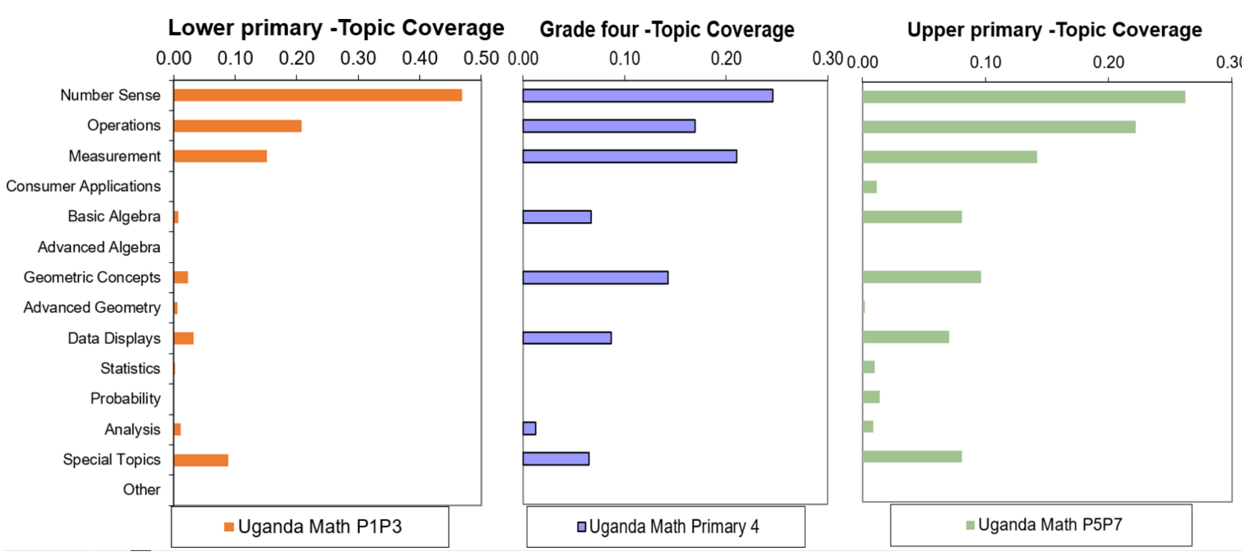

Figure 1(b): Mathematics curriculum standards - relative emphasis on topics

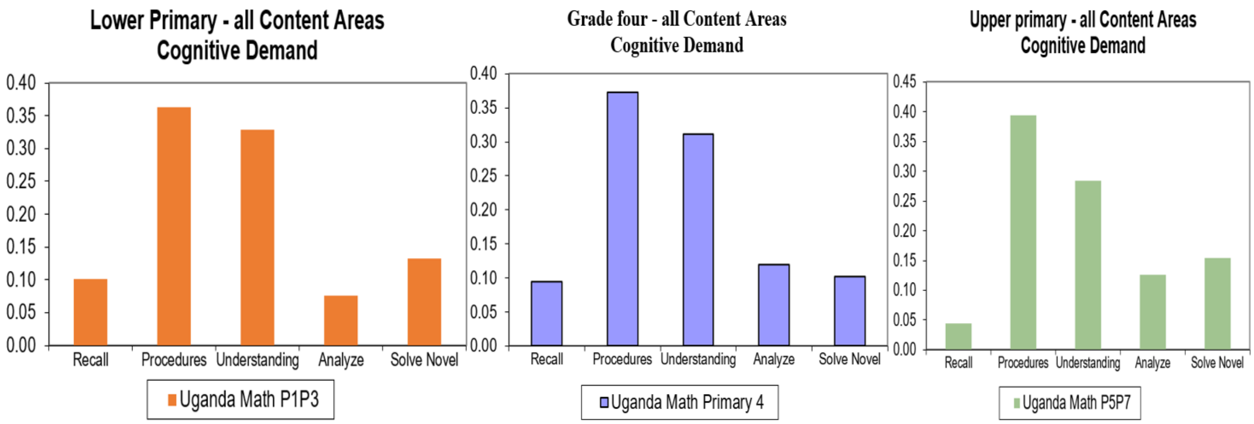

Figure 1(c): Mathematics curriculum standards - relative emphasis on cognitive demand

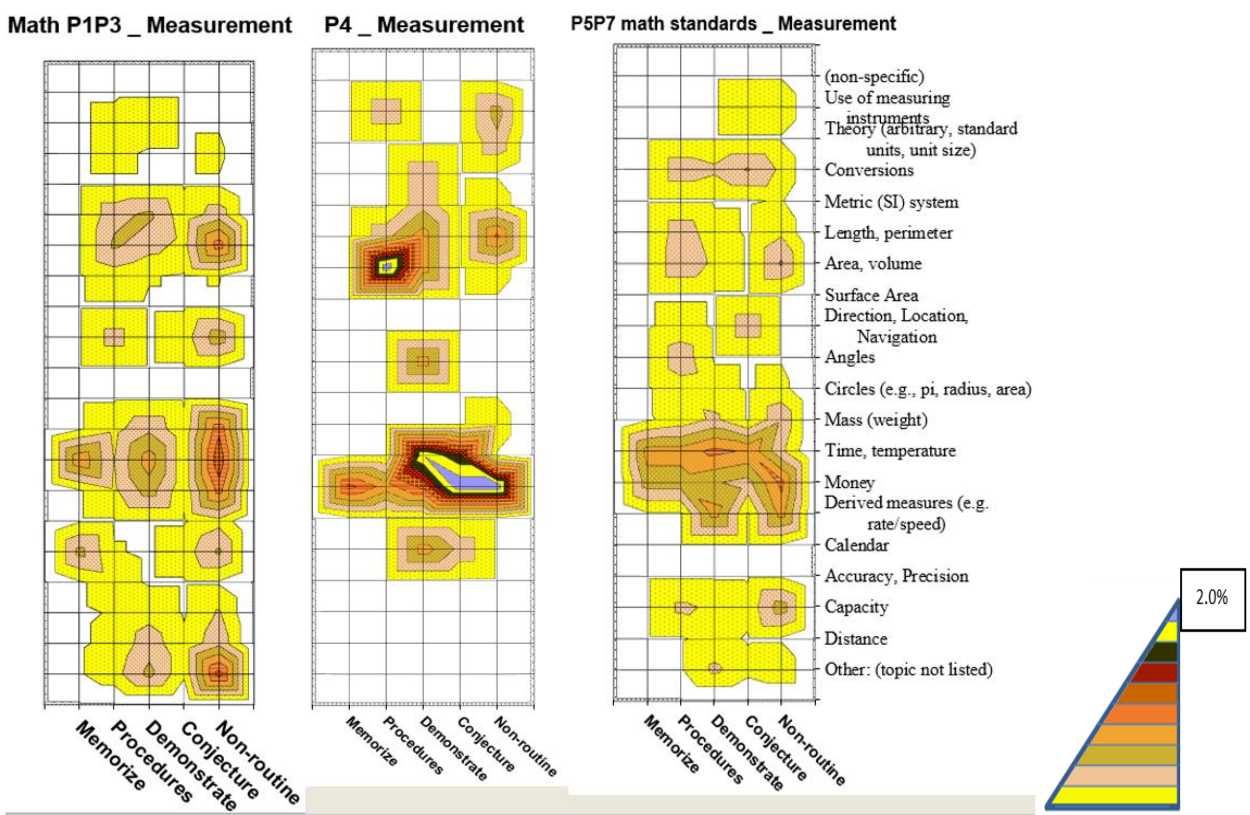

Figure 1(d): Mathematics curriculum standards – fine grain sub-topic level analysis, 'measurement'

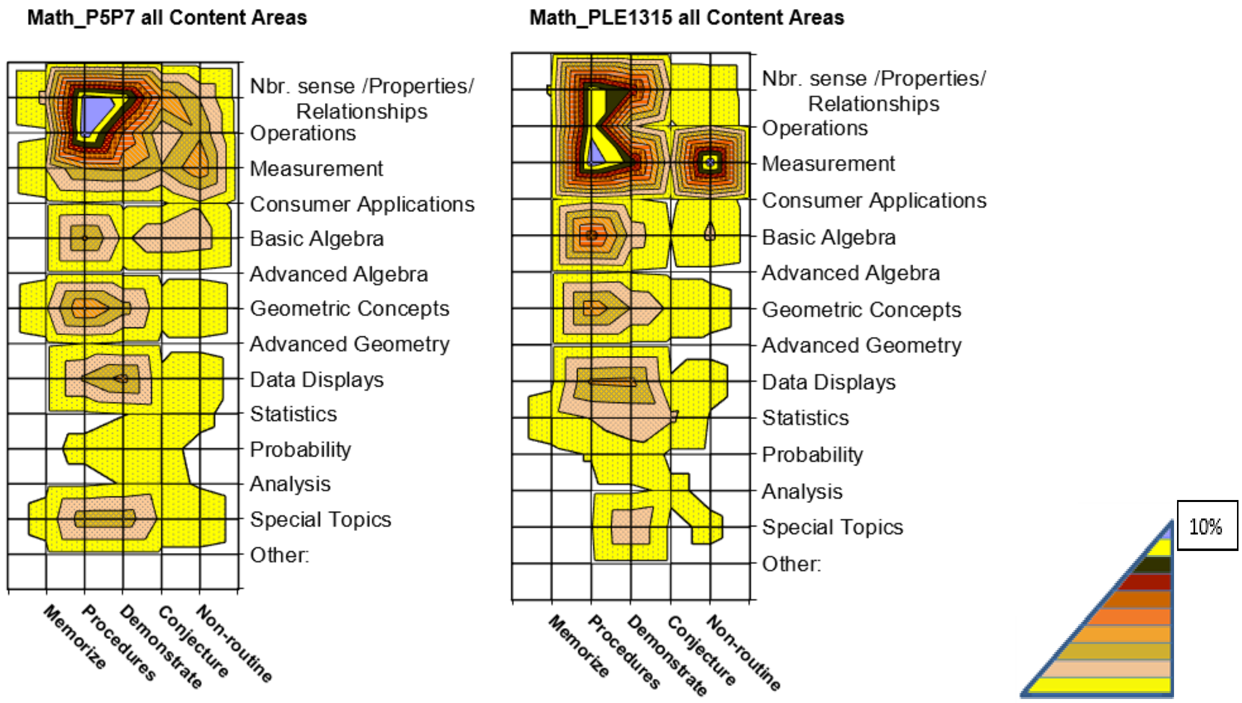

Figure 2(a): Alignment analysis – Upper primary curriculum standards versus End of primary national examinations

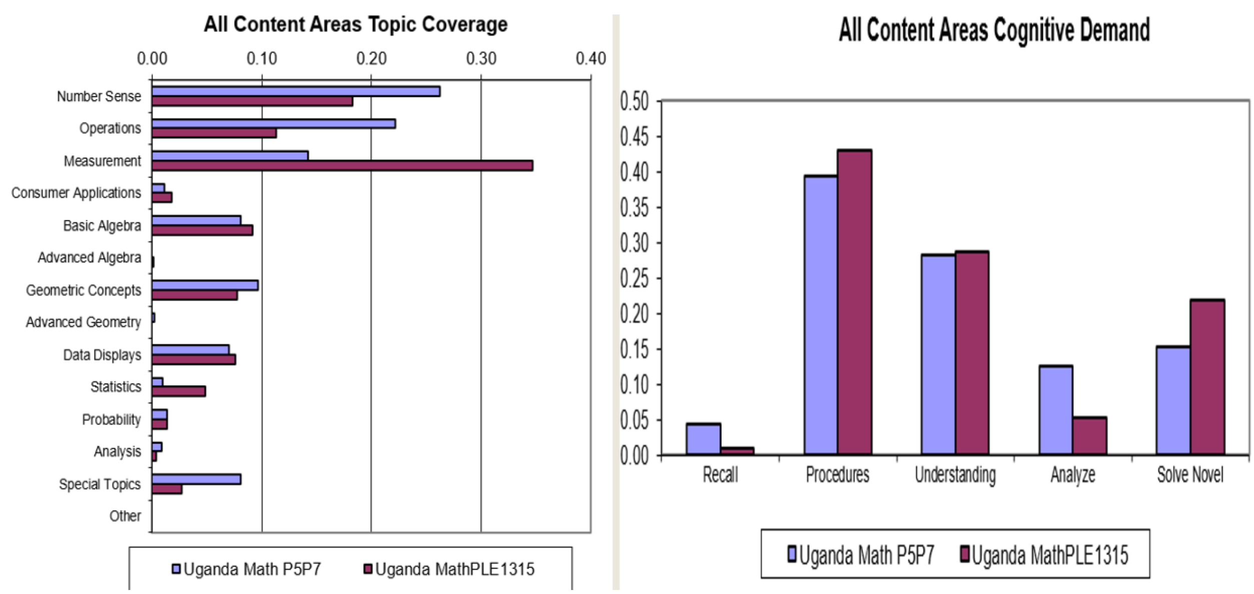

Figure 2(b): Alignment analysis marginal charts – Upper primary curriculum standards versus PLEs

Table 1. Alignment Analysis Summary Table

Uganda Math P1-P7 TO: Uganda MathPLE13-15	Alignment	Balance of Representation	Categorical Concurrence (Topics)	Cognitive Complexity (Cog. Dmnd.)
Number Sense	0.29	0.22	0.37	0.87
Operations	0.47	0.10	0.55	0.18
Measurement	0.57	-0.19	0.75	0.62
Consumer Applications	0.51	-0.01	0.56	0.59
Basic Algebra	0.33	-0.06	0.16	0.68
Advanced Algebra	#DIV/0!	0.00	#DIV/0!	#DIV/0!
Geometric Concepts	0.26	-0.03	0.44	0.79
Advanced Geometry	#DIV/0!	0.00	#DIV/0!	#DIV/0!
Data Displays	0.40	-0.03	0.46	0.77
Statistics	0.38	-0.04	0.65	0.50
Probability	0.56	-0.01	1.00	0.56
Analysis	0.93	0.01	1.00	0.93
Special Topics	0.40	0.06	0.99	0.40
Other	#REF!	0.00	#REF!	#REF!
Overall	**0.33**	**0.61**	**0.44**	**0.57**

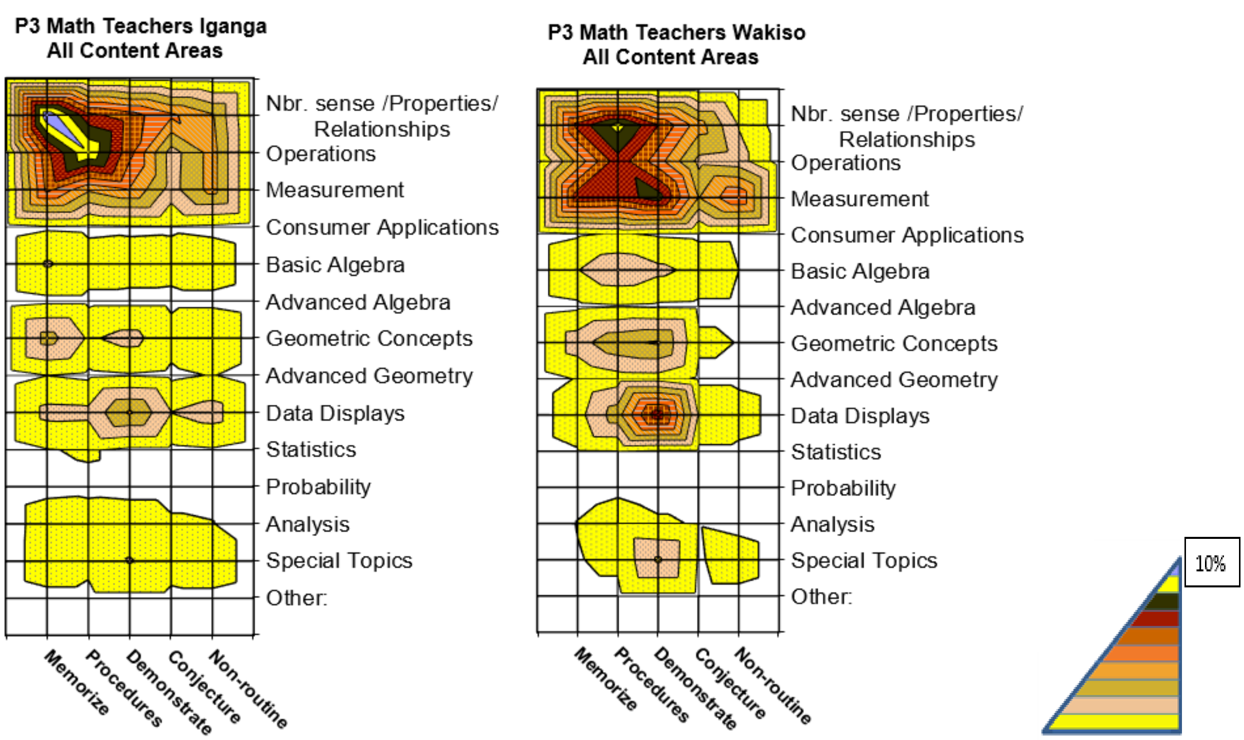

Figure 3(a): Rural versus urban grade three mathematics teachers' content coverage.

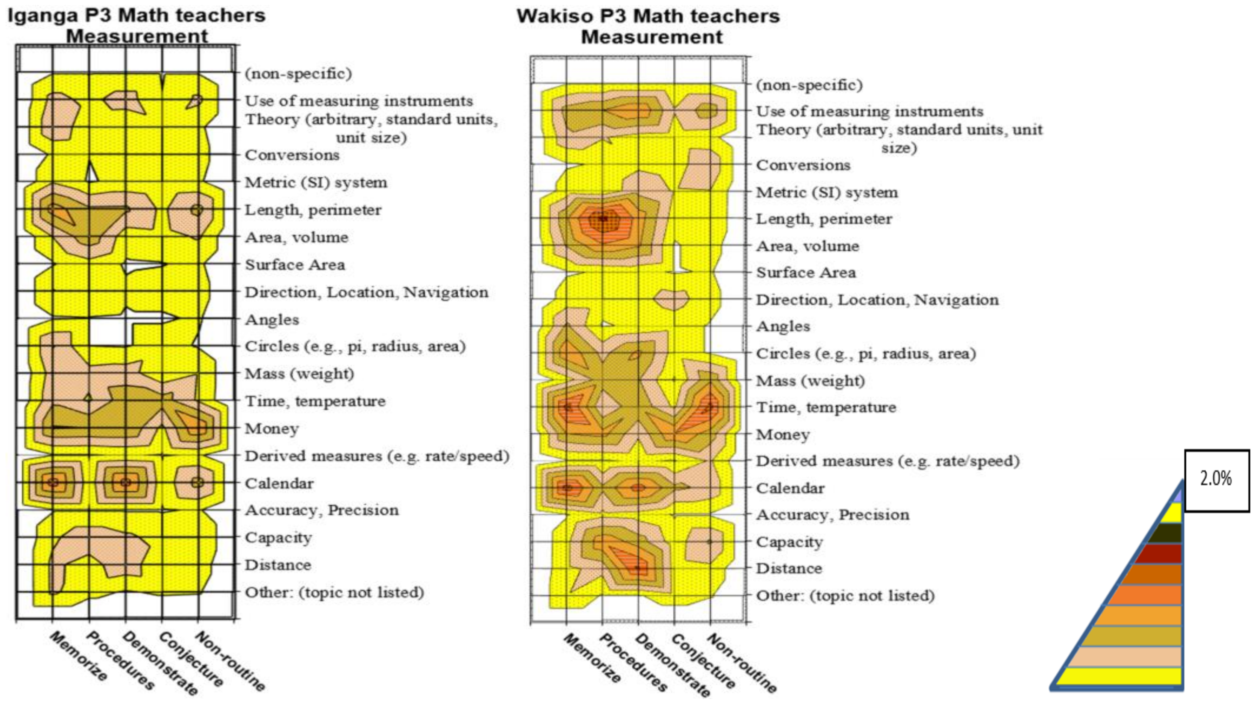

Figure 3(b): Rural versus urban grade three mathematics teachers' fine-grain analysis, 'measurement'.

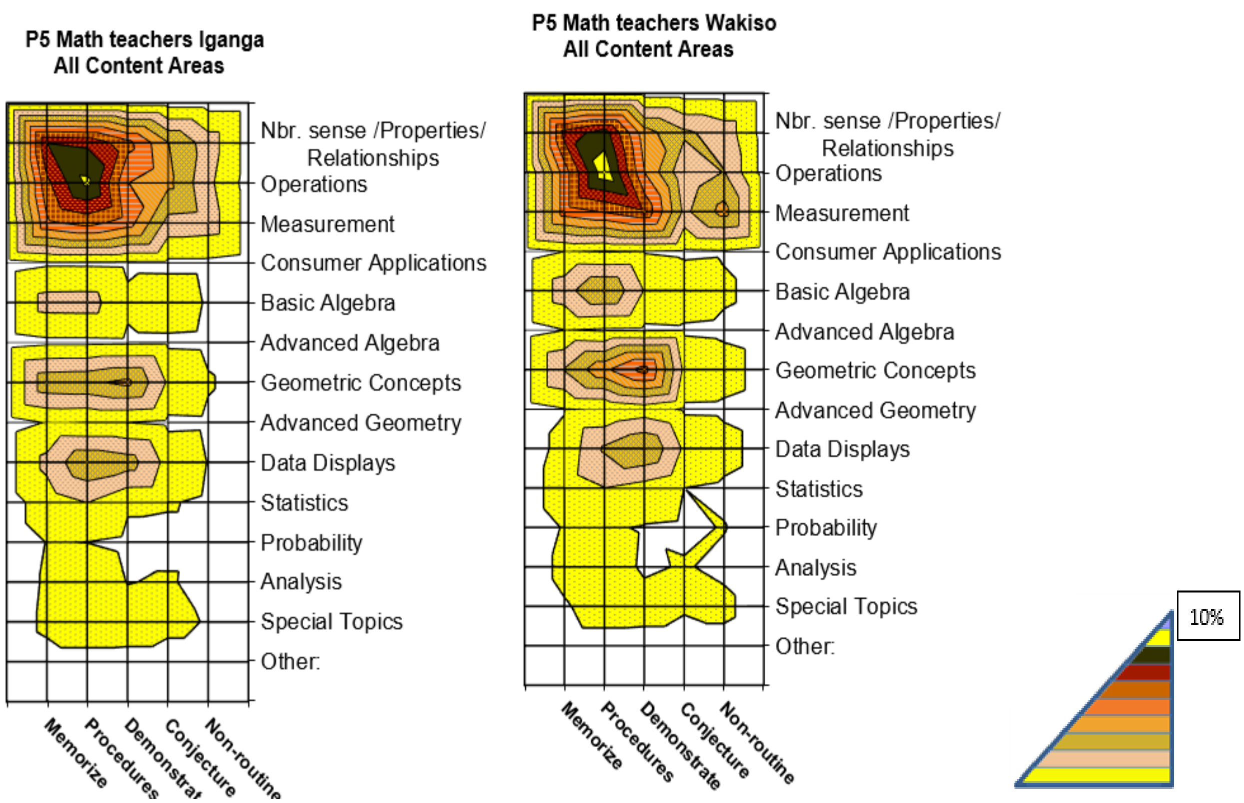

Figure 3(c): Rural versus urban grade five mathematics teachers' content coverage.

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Annex A1: Cognitive demand matrix for Mathematics

Cognitive Demand Categories for Mathematics

B	C	D	E	F
Memorize Facts, Definitions, Formulas	**Perform Procedures**	**Demonstrate Understanding of Mathematical Ideas**	**Conjecture, Analyze, Generalize, Prove**	**Solve Non-Routine Problems / Make Connections**
Recite basic mathematical facts	Use numbers to count, order, denote	Communicate mathematical ideas	Determine the truth of a mathematical pattern or proposition	Apply and adapt a variety of appropriate strategies to solve non-routine problems
Recall mathematics terms and definitions	Do computational procedures or algorithms	Use representations to model mathematical ideas	Write formal or informal proofs	Apply mathematics in contexts outside of mathematics
Recall formulas and computational procedures	Follow procedures / instructions	Explain findings and results from data analysis strategies	Recognize, generate or create patterns	Apply to real world situations
	Solve equations/formulas/ routine word problems	Develop/explain relationships between concepts	Find a mathematical rule to generate a pattern or number sequence	Synthesize content and ideas from several sources
	Organize or display data	Show or explain relationships between models, diagrams, and/or other representations	Make and investigate mathematical conjectures	
	Read or produce graphs and tables		Identify faulty arguments or misrepresentations of data	
	Execute geometric constructions		Reason inductively or deductively	

Annex A2: Contextualized Taxonomy for Primary Mathematics – Uganda

Mathematics Taxonomy - Uganda

100	**Nbr. sense /Properties/ Relationships**
101	Place value
102	Whole numbers and Integers
103	Operations
104	Fractions
105	Decimals
106	Percents
107	Ratio and proportion
108	Patterns
109	Real and/or Rational numbers
110	Exponents and scientific notation
111	Factors, multiples, and divisibility
112	Odd/even/prime/composite/square numbers
113	Estimation
114	Number Comparisons (order, magnitude, relative size, inverse, opposites, equivalent forms, scale or number line)
115	Order of operations
116	Relationships between operations
117	Number Theory (e.g. base-ten and non-base-ten systems)
118	Mathematical properties (e.g., distributive property)
190	Other
200	**Operations**
201	Add/subtract whole numbers and integers
202	Multiply whole numbers and integers
203	Divide whole numbers and integers
204	Combinations of operations on whole numbers or integers
205	Equivalent and non-equivalent fractions
206	Add/subtract fractions
207	Multiply fractions
208	Divide fractions
209	Combinations of operations on fractions
210	Ratio and proportion
211	Representations of fractions
212	Equivalence of decimals, fractions, and percents
213	Add/ subtract decimals
214	Multiply decimals
215	Divide decimals
216	Combinations of operations on decimals
217	Computing with percents
290	Other

300	**Measurement**
301	Use of measuring instruments
302	Theory (arbitrary, standard units and unit size)
303	Conversions
304	Metric (SI) system
305	Length and perimeter
306	Area and volume
307	Surface Area
308	Direction, Location
309	Angles
310	Circles (e.g., pi, radius, area)
311	Mass (weight)
312	Time and temperature
313	Money
314	Derived measures (e.g., rate and speed)
315	Calendar
316	Accuracy and precision
317	Capacity
318	Distance
390	Other
400	**Consumer Applications**
401	Simple interest
402	Rates (e.g., discount and commission)
490	Other
500	**Basic Algebra**
501	Absolute value
502	Use of variables
503	Evaluation of formulas, expressions, and equations
504	One-step equations
505	Coordinate Planes
506	Patterns
507	Multi-step equations
508	Inequalities
509	Linear and non-linear relations
510	Rate of change/slope/line
511	Operations on polynomials
512	Factoring
513	Square roots
590	Other

600	**Advanced Algebra**
601	Rules for exponents
690	Other
700	**Geometric Concepts**
701	Basic terminology
702	Points, lines, rays, segments, and vectors
703	Patterns
704	Similarity
705	Parallels
706	Triangles
707	Quadrilaterals
708	Circles
709	Angles
710	Polygons
711	3-D relationships
712	Symmetry
713	Transformations (e.g., flips or turns)
714	Pythagorean Theorem
790	Other
800	**Advanced Geometry**
801	Spheres, cones, and cylinders
802	Coordinate Geometry
890	Other

900	**Data Displays**
901	Summarize data in a table or graph
902	Bar graph and histograms
903	Pie charts and circle graphs
904	Pictographs
905	Line graphs
906	Venn diagrams
990	Other
1000	**Statistics**
1001	Mean, median, and mode
1002	range
1090	Other
1100	**Probability**
1101	Simple probability
1190	Other
1200	**Analysis**
1201	Sequences and series
1290	Other
1300	**Special Topics**
1301	Sets
1390	Other

Annex A3: An example of a two-dimensional matrix of topic/subtopic codes and cognitive demand levels

26a	Using a ruler, a pencil and a pair of compasses only: Construct a parallelogram ABCD such that line AB = 7 cm, BC = 5 cm and angle ABC = 120°	P47.31	707	C		
	ii) Drop a perpendicular from D to meet AB at M.	P47.32	709	C		
26b	Measure the line DM	P47.33	316	C		
27a	The time table shows how a pupil spent his time one Saturday. How long did he take playing?	P47.34	312	D	204	C
27b	If he dug maize garden at a rate of 2 rows in every 30 minutes, find the number of rows he dug that day.	P47.35	314	D		
28	The exchange rate for Kenya Shillings (K sh.) to Uganda (Ug Sh. and the United states dollars (Us$) to Uganda shillings are shown below. Ksh 1 = Ug sh. 30. Us$ = Ug. sh. 2580. How many United states dollars will one get from 21,500 Kenya shillings?	P47.36	303	C	313	F
28b	If the cost of a new bicycle is 90 United States dollars, how much would this be in Uganda shillings	P47.37	303	C		
29	At Kampala Bus Park, buses travelling to Arua and Mbarara leave after every 40 minutes and 50 minutes respectively. The first buses to the two towns leave together at 6:00am. At what time will buses to the two towns leave Kampala together again?	P47.38	312	F	312	E
30a	The mean of numbers 7,9,5,x+2 and 6 is 8. Find the value of x	P47.39	1001	D	503	D
30b	In a bag there are 15 pens. Out of these 4 are red and the rest blue. What is the probability that a pen picked at random from the bag is blue?	P47.40	1101	C		
31a	Nanziri has two children a son and a daughter. If the son is half her age, the daughter is a third of her age and the total age of the two children is 30 years. Find Nanziri's age	P47.41	507	F	503	F
31b	How old is the daughter	P47.42	507	D	503	D
32 a	A school wants to fence a circular flower garden of diameter 14 m using poles placed at intervals of 80 cm. How many poles are needed to fence the flower garden? (Take Pi = 22/7).	P47.43	310	D	503	F
32b	If each pole costs sh. 3000, how much money will the school spend on the poles?	P47.44	202	D		

... P3-Math P4-Math P5-Math P6-Math P7-Math PLE-2013 **PLE-2014** PLE-2015