A Regional Exploration of Pathways Toward Harmonization of Math & Science Curriculum in the East African Community

Discussion Paper

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Foreword

Prior to the breakup of the old East African Community (EAC) in 1977, the East African countries shared a harmonized education system. However, after 1977, the countries adopted different systems and curricula to reflect their individual national aspirations.

The re-establishment of the East African Community (EAC) in 2000, and the deepening of regional cooperation, especially for enhanced labor mobility, once again focuses attention on the need for a harmonized system for human resource development. As a first step to achieving this, the EAC identified harmonizing curriculum as a priority goal.

The leadership of the EAC countries, individually and collectively, recognizes the importance of science and technology as engines of growth, development, and competitiveness. Harnessing science and technology, however, remains a challenge across the region. Low overall enrollment at the tertiary level, of which only a very small percentage is in scientific and technical fields, is but one indicator of this challenge. Creating a groundswell of human resources able to effectively wield science and technology for national and regional development starts in schools, where the foundations of math and science proficiency are formed.

Harmonizing the region's curriculum is not a small task. Significant political will and regional coordination is required to bring this goal to fruition. Math and science provides an excellent starting point toward achieving this goal. The subject matter content already is more harmonized than more culturally dependent areas like language and history. It also offers EAC Partner States an opportunity to strengthen science and mathematics capacity throughout the region.

The World Bank greatly appreciates the opportunity to support this regional harmonization effort. For this reason, it is sponsoring a Ministerial-level workshop entitled "A Regional Exploration of Pathways Toward Harmonization of Math and Science Curriculum in the East African Community" on 21-23 September 2011. The workshop is designed to allow for discussion on the steps needed to achieve regional math and science curriculum reform. Understanding that enhanced science and mathematics curriculum is but one ingredient required to boost learning outcomes, the workshop will also explore opportunities for wider systemic improvements in the areas of policy and governance, teaching and learning resources, teacher training, and evaluation of learning outcomes. Our hope is that this regional exercise will contribute to creating favorable conditions for enhanced labor and academic mobility in the region, through raised teaching and learning standards in math and science education and the promotion of recognizable standards in these subjects within the EAC.

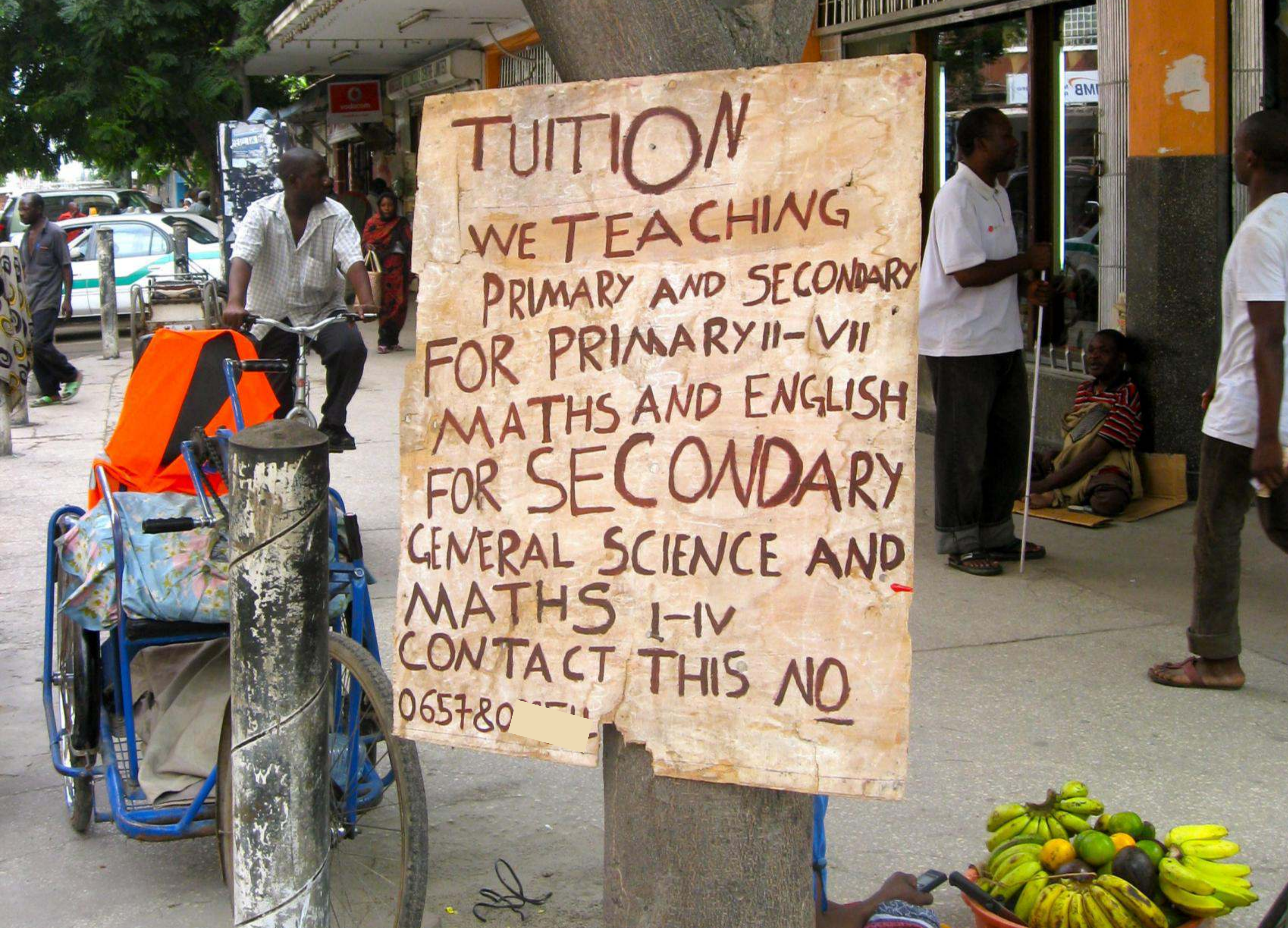
This discussion paper intends to provide the regional context for what we hope will be a stimulating dialogue. It is based on extensive interviews with a wide range of stakeholders from the five EAC Partner States, ranging from math and science education policy makers, to math and science teachers and students, to representatives from the private sector and scientific community.

We look forward to this regional workshop as an opportunity to create pathways for collaborative, near-term initiatives to harmonize and strengthen regional math and science education. We see this step as an advance towards a brighter future in which innovation drives economic growth and development in East Africa.

Peter Materu
Acting Sector Manager
Education Unit
Human Development
Africa Region
World Bank

Abbreviations

ASEI	Activity, Student, Experiment, and Improvisation
BEPES	Bureau of Studies and Secondary Education Curriculum Development (Burundi)
CDF	Constituencies Development Fund (Kenya)
CEMASTEA	Centre for Mathematics, Science, and Technology Education in Africa
EAC	East African Community
IAB	Industrial Association of Burundi
ICT	Information and communication technologies
INSET	In-service education and training
JICA	Japanese International Cooperation Agency
M&S	Math and science
MoEVT	Ministry of Education and Vocational Training (Tanzania)
PDSI	Plan, Do, See, Improve
PSF	Private Sector Federation (Rwanda)
SEIA	Secondary Education in Africa
SESEMAT	Secondary School Science and Mathematics Teachers
SMASE-WECSA	Strengthening Math and Science Education in Western, Eastern, Central & Southern Africa
SMASSE	Strengthening of Mathematics and Science in Secondary Education
STI	Science, technology, and innovation
TEA	Tanzania Education Authority
TVET	Technical and Vocational Education and Training
UMA	Uganda Manufacturers Association
UNESCO	United National Educational, Scientific, and Cultural Organization



Executive Summary

The East African Community (EAC) Partner States of the Republics of Kenya, Uganda, Rwanda, Burundi, and the United Republic of Tanzania, identified the "harmonization of the education curricula, standards, assessment, and evaluation of education programs as a priority issue" in the EAC treaty (EAC, "Treaty for the Establishment of the East African Community," Articles 5 and 102, 2007). Intrigued by the possibility of systemic improvements achieved more efficiently, affordably, and/or to greater effect by way of partnership, the EAC argues "through innovative forms of collaboration, education can systematically be improved against common agreed benchmarks of excellence, thereby facilitating the mobility of students and teachers across countries." (EAC Secretariat, "Study on the Harmonization of the East African Education Systems and Training Curricula," 2011).

There are a number of reasons why focusing education harmonization efforts on math and science education is warranted at this juncture. First, science and math skills form the foundation for the regional integration and labor market mobility the EAC Partner States seek. In particular, secondary school graduates require proficiency in math and science now more than ever as they enter labor markets that "increasingly demand modern knowledge and skills, readiness to take initiatives, and ability to solve problems and to innovate products and processes" (Ottevanger, van den Akker, de Feiter, "Developing Science, Mathematics, and ICT Education in Sub-Saharan Africa: Patterns and Promising Practices," 2007). Second, poor math and science education at the secondary level often condemns graduates to low-paying jobs, or worse, unemployment, not to mention insufficient preparation to deal with a host of science issues pertinent to a healthy and productive life. At a societal level, low levels of scientific and technical skills in industry thwart competitiveness, rendering national goals for economic growth and development more difficult to achieve. Third, greater convergence exists in secondary math and science education curricula across the EAC Partner States than in other more culturally influenced fields such as language and history. Physics is physics whether one is in Kenya, Burundi, or Uganda. Thus, math and science education harmonization provides a relatively uniform platform on which to initiate regional coordination. Success in piloting harmonization approaches in these disciplines will provide valuable insight into the harmonization of other potentially more divergent educational areas.

The World Bank recognizes the opportunity available to enhance math and science education through regional harmonization and collaboration, and is committed to supporting this process. As such, the World Bank, in partnership with the EAC Secretariat, invited high-level policy makers and practitioners from across the five Partner States to come together to discuss opportunities for regional harmonization of secondary math and science education within the EAC. In advance of this Ministerial Forum, the World Bank sponsored an intensive research and analysis process that involved field research in each of the five Partner States. Over a two-month period, a six-person team of science education and research specialists conducted interviews and desk research that resulted in this Discussion Paper.

Taking a systems-based approach, the six-person research team looked across and within five essential and inter-related pillars of secondary math and science education. The five pillars inform the quality of learning outcomes achieved by secondary students in math and science. The five pillar structure, and the major regional trends and findings for each, are listed below and discussed in greater detail in the following analysis. The findings and considerations for regional harmonization are not just designed to prompt informed discussion during the regional dialogue. They also are devised as a springboard toward longer-term regional cooperation for harmonizing secondary math and science education.

The chapters—each of which addresses one pillar in turn—provide case studies and discussion specific to each. Key take-aways pertinent to each pillar are highlighted below.

Pillar I: Policy and governance of secondary math and science education

- Political commitment to support math and science education is apparent across the EAC
- Multiple innovation drivers, outputs, and outcomes are at play
- Assuring quality effectively is an ongoing challenge
- Questions of influence, accountability, & contribution to planning persist

Pillar II: Secondary math and science curricular content

- The EAC region is moving toward competency-based alternatives
- Tensions exist between competency-based approaches and curricular features
- Private sector is not satisfied with outcomes, but keen to help
- Barriers to curricular implementation impede progress

Pillar III: Teaching and learning resources for secondary math and science education

- There is a premium on understanding the backdrop of teaching and learning resource needs
- Resources defined as essential vary across EAC Partner States
- For resources in use, their location and access matter
- Interesting opportunities for sharing resources exist in the region

Pillar IV: Secondary math and science teacher training, professional development, and pedagogy

- Distinct and diverse pathways exist that lead toward becoming a secondary math and science teacher across the EAC
- Different approaches to recruiting secondary math and science teachers prevail
- Retaining secondary math and science teachers is a consistent challenge
- Excellence is fostered through enhanced pedagogical training

Pillar V: Evaluation of secondary math and science learning outcomes

- Evaluation processes are dominated by centrally-administered exams
- Negative perceptions of math and science skew student interest
- Preparation at secondary level is geared for higher education, not employment
- Poor alignment within the system diminishes math and science learning outcomes

Despite the treatment of math and science education according to a five pillar structure, any attempt to carve clean lines between these inter-related aspects of education is inherently suspect. Not surprisingly, a number of important insights emerge at the intersection of pillars. First, while certain striking intra-regional differences exist (e.g., number of years of secondary schooling), the research reveals close alignment between EAC Partner States in terms of secondary math and science education on many fronts. Such congruence bolsters the case for regional harmonization in secondary math and science education. It also points to a number of near-term collaborative opportunities that are within reach.

Second, where differences exist, they often constitute examples from which regional neighbors can learn from one another, rather than major barriers to harmonization. Examination of such divergences may afford the other Partner States the chance to replicate good practice. Finally, though feedback on the prospect of regional harmonization of secondary math and science education was generally positive, it was not free from concern.

Maintaining a focus on harmonizing *outputs* and *outcomes* of secondary math and science education, not necessarily *inputs,* allows stakeholders to prioritize actions that ensure students exit secondary school with the skills and knowledge they need to compete and contribute in national and regional innovation systems.

"Through innovative forms of collaboration, education can systematically be improved against common agreed benchmarks of excellence, thereby facilitating the mobility of students and teachers across countries."

-- EAC Secretariat, Study on the Harmonization of the East African Education Systems and Training Curricula

Introduction

Why math and science?

Meet Mary. Mary sits at a desk in her lower secondary school classroom riveted by what she sees in front of her. She's in her O-level chemistry class, watching intently as two liquids swirl and interact. One is water from Lake Victoria, which laps at the banks of Entebbe less than a kilometer from her school. The other is bromothymol blue-a chemical her teacher introduces to the lake water to demonstrate the way pollutants can lead to oxygen depletion in the water. Mary thinks of the Nile Perch, her favorite choice for dinner, and wonders how this chemical reaction changes the prospects of fish life. She asks questions. She wonders how, if left unchecked, such chemical reactions could destroy an industry on which her society, and indeed her family (her father is a fisherman) depend. Her mind races. She envisions a future helping her people through chemistry. Mary's love of chemistry compels her to take as many math and science classes as she can. She enters a competition through Uganda's National Science Week, submitting a paper on the role of national and regional regulations reducing chemical effluents into Lake Victoria. She wins! Her appetite for science increases. Any moment she spends on a computer she devotes to searching for articles on lake ecology, aquatic flora and fauna, and chemistry. With passion and curiosity she soars through her A-levels and secures a scholarship—one of the 75% of federally funded awards designated for science and engineering studies—to Makerere University. With a Bachelors degree in Chemistry and a focus on marine biology, she secures an internship with the Fisheries Resources Research Institute. After university, she lands a job with the Ministry of Agriculture, Animal Industry and Fisheries. She performs outreach to fishermen's groups across the Lake Victoria Basin, educating them on ways to identify and abate lake pollution. She falls asleep each night, listening to the waves lap at Victoria's shores, knowing her work contributes directly to a US$ 100 million per year industry. When sleeping, she dreams that her daughter will one day break new ground in chemistry, perhaps win a Nobel Prize, driving her nation's continued progress toward harnessing science for development.

Consider Mary's journey and the many variables that bear on her educational and professional success in science. The pillars buttressing this discussion paper consolidate these variables into meaningful categories, five in total, that each spell the difference between a country and a region bountiful in students like Mary and millions like her, or limited in the human and institutional resources required to drive a knowledge economy and fuel economic and social progress.

Research methodology and approach

How might we take an innovation systems approach to harmonizing secondary math and science education?

The World Bank devised a holistic, multi-pronged approach to research, analysis, and design to support cooperation in advance of, during, and after a September 2011 regional dialogue on harmonizing secondary math and science education. Using the EAC's definition of harmonization and focus on labor market mobility, the research team took a systems-based approach to understanding how the *inputs* to the secondary math and science education process (e.g., curricular content, pedagogical training for teachers, and learning resources) can be aligned and enhanced through knowledge production processes (education policies and evaluation guidelines) to deliver an *output* of the secondary education system (e.g., skilled, employable individuals—like Mary) that contributes meaningfully to enhancing desired *outcomes* of the national and regional innovation system (e.g., adding value to economic growth, competitiveness, development).

The innovation systems approach considers a number of variables with which policy makers and other stakeholders must contend in approaching secondary math and science education harmonization. These factors are organized into a pillar structure to facilitate efficient research, data gathering, discussion, strategy-setting, and, ultimately, action. Intersections and overlaps among the five pillars, listed below, are implicit, insightful, and indeed expected given system dynamics and inter-relationships.

Pillar I: Policy and governance of secondary math and science education

Pillar II: Secondary math and science curricular content

Pillar III: Teaching and learning resources for secondary math and science education

Pillar IV: Teacher training, professional development, and pedagogy for secondary math and science education

Pillar V: Evaluation of secondary math and science learning outcomes

A six-person team visited all five EAC countries to collect data and insights on secondary math and science education per the five-pillar structure. The research team conducted over 120 interviews with a multitude of stakeholders, among them: representatives of government, private sector, the non-profit community, scientific societies, universities, teachers, students, and others. The researchers compiled almost 600 pages of unique insights, quotes, and data points. In many cases, the information gathered is particularly valuable given its paucity in any other report to date. Many of the insights gleaned through interviews are not readily "findable" from outside the Partner States and thus likely missing from current discussions of regional education harmonization.

The discussion paper presents a synthesis of the research team's findings. It is organized per the pillar structure and presents the four most relevant regional trends and/or insights in each, buttressed with country-based examples and considerations for regional harmonization. Meant to provoke questions and ideas in advance of the stakeholder dialogue, the paper *does not* offer a comprehensive analysis of the secondary math and science education systems in the EAC. It is instead a provocation informed by critical stakeholders. For this reason, the information provided focuses more on interesting examples and perspectives provided through primary research rather than statistics and explanations of process, policy, or procedure of the kind readily accessible through desk research. Readers are invited to refer to the EAC Study on the Harmonization of the East African Education Systems and Training Curricula (2011) for information regarding Partner States' education structures, national priorities for education, admittance criteria, financing strategies, and other details regarding their current educational systems.

Background on the East African Community (EAC) education harmonization agenda

To facilitate the Regional Integration process and especially the free movement of human resources, the EAC Partner States of the Republics of Kenya, Uganda, Rwanda, Burundi, and the United Republic of Tanzania, identified the "harmonization of the education curricula, standards, assessment and evaluation of education programs as a priority issue" in the EAC Treaty (EAC, 2007). Articles 5 and 102 of the EAC Treaty articulate this shared vision which requires, among other things, for Partner States to:

(1) Coordinate their human resource development policies and programs;
(2) Develop such common programs in basic, intermediary and tertiary education and a general program for adult and continuing education in the partner states as would promote the emergence of well trained personnel in all sectors relevant to the aims and objectives of the community;
(3) Harmonize curricula, examination, certification and accreditation of education and training institutions in the Partner States through the joint action of the relevant national bodies charged with the preparation of such curricula;
(4) Encourage and support the mobility of students and teachers within the community;
(5) Exchange information and experience on issues common to the education systems in Partner States (ibid).

So what does harmonization actually mean? Harmonization, according to the EAC, does not denote "uniformity, congruency, or the development of a singular education system for the five Partner States." Neither does it imply the "glorification or recommendation of one country system and the vilification of another or others." Rather, the EAC promotes harmonization as a means of achieving an "increasingly networked and interrelated group of curriculum and examination systems, linked in such a way that these systems possess overlapping, interconnected, and comparable logics that are capable of influencing each other across the Partner States" (EAC Secretariat, 2011). The rationale for education harmonization is that "through innovative forms of collaboration, education can systematically be improved against common agreed benchmarks of excellence, thereby facilitating the mobility of students and teachers across countries" (ibid).

Rationale for supporting secondary math and science education as a focal point for the education harmonization agenda

Science and math skills form the foundation for the regional integration and labor market mobility the EAC Partner States seek. Secondary school graduates require proficiency in math and science now more than ever as they enter labor markets that "increasingly demand modern knowledge and skills, readiness to take initiatives, and ability to solve problems and to innovate products and processes" (Ottevanger, van den Akker, de Feiter, 2007). Indeed, secondary math and science education underpins a capability in science, technology and innovation (STI) that forms a cornerstone for economic growth, poverty alleviation, and competitiveness in both the African and global contexts.

One reason for prioritizing math and science in this exercise is the undeniable fact that poor performance in math and science comes at a high social cost. The result of poor math and science education at the secondary level is a low level of scientific and technical skills in industry, which can thwart competitiveness due to low technology and knowledge content of goods and services. In today's rapidly changing global economy, the critical economic development issue is no longer whether countries should build STI capacity but what type of capacity to build and how to build it, given each country's constraints and unique starting points (Watkins and Ehst, 2007).

Another motivation for unpacking the prospects for math and science harmonization is the greater convergence that exists in secondary math and science education curricula across the EAC Partner States compared to other more culturally influenced fields such as language and history. Physics is physics whether one is in Kenya, Burundi, or Uganda. Thus, secondary math and science education harmonization provides a relatively uniform platform upon which to initiate this aspect of regional coordination. Success piloting harmonization approaches in these disciplines will provide valuable insight to inform the harmonization of other potentially more divergent educational areas.

The World Bank recognizes the opportunity available to enhance secondary math and science education through regional harmonization, and is committed to supporting this process by building on previous achievements in the region. Each of the EAC Partner States engaged in previous efforts undertaken through World Bank support and direct federal government commitment to boost the quality, access, and relevance of secondary education. One specific World Bank-funded effort--the 2008 Secondary Education in Africa Program (SEIA)--sought to support African countries as they developed, implemented, and improved national strategies for secondary education and training. Developing science, mathematics, and information and communication technology (ICT) education in Sub-Saharan Africa constituted one of the eight thematic thrusts of the SEIA program (Ottevanger, van den Akker, de Feiter, 2007). Separately, the World Bank supported a four-year study, entitled "Science, Technology, and Innovation in Uganda" (Brar, Farley, Hawkins, and Wagner, World Bank 2011) that found, in general, the math and science skills of the Ugandan workforce failed to meet industrial need across a range of key sectors—agriculture, health, energy, ICT, transport and logistics. A critical bottleneck cited by industry leaders interviewed for that study was the lack of opportunities to integrate industry needs into math and science-based curriculum development. These and other investments denote the World Bank's long-standing support for enhancing STI capacity in the East Africa region.

The World Bank, in partnership with the EAC Secretariat, invited a group of high-level policy makers and practitioners from across the five Partner States to discuss opportunities to move forward regional harmonization of secondary math and science education. This Ministerial Dialogue, which will be held in Arusha, Tanzania in September 2011, aims to:

(1) Deepen insights into the landscape of secondary math and science education in the region,
(2) Examine lessons learned with respect to regional efforts to enhance the quality of learning outcomes associated with secondary math and science education,
(3) Identify strategic pillars around which efforts to harmonize secondary math and science education in the region can be organized.

This World Bank-led effort is not occurring in isolation of broader EAC harmonization activities. The EAC Secretariat undertook a "Study on the Harmonization of the East African Education Systems and Training Curricula" that involved 13 working groups of multiple stakeholders to explore the possibilities of education harmonization in the EAC more broadly. Completed in 2011, the study presents a comprehensive picture of the current status of national education systems, including commonalities and significant differences that exist across the Partner States. The World Bank seeks to build off of, not replicate, the priorities and foundational research conducted by the EAC, and has used the EAC's findings and insights as the starting point for this more targeted inquiry. This activity sharpens the focus on math and science. It infuses the voices of teachers, students, principals, examiners, Education Ministers, curriculum developers, job-seekers, job-makers, industrialists, and scientists themselves into the text wherever possible. With these opinions and observations organized as fodder for discussion, the workshop participants are invited to engage in a rich, promising, and vital regional dialogue.

"We should involve the consumers, involve the industry a little more, because they should tell us what kind of students they want."

-- Head, Computer Studies Department, Kenya Technical Teachers College

Pillar One: Policy and Governance

Key M&S secondary education policy and governance trends at the EAC regional level:

- ***Political commitment to support math and science education apparent***
- ***Multiple innovation drivers, outputs, and outcomes at play***
- ***Assuring quality effectively is an ongoing challenge***
- ***Questions of influence, accountability, & contribution to planning persist***

Political commitment to support math and science education apparent

Across the East African Community, governments exert a significant amount of political support for enhancing educational opportunities, especially in the fields of math and science. Many Partner States in the EAC assert an intent to transform into "knowledge-based economies" which requires investment to build a human resource base that can effectively wield the tools of science and technology for national and regional development. This human resource base is not limited to highly skilled science and engineering professionals. Rather, knowledge economies depend on the contribution of a broader population proficient in math and science. The increased political will toward cultivating math and science proficiency elicited mention by many sources interviewed.

High-level policy documents in each of the five EAC country contexts (see textbox for examples) reflect a shared commitment on behalf of the five country governments. Rather general in nature, however, the lack of specificity on essential aspects of math and science secondary education manifests in the fact that countries' implementation of these policy statements varies considerably.

Box 1: High-level Policy Support for Secondary Math and Science Education, EAC Examples

- One of Burundi's adopted education objectives for 2015 is to "reinforce the teaching of science, mathematics, and technology."
- Kenya's Vision 2030 asserts the country "intends to have international ranking for her children's achievement in maths, science and technology."
- Rwanda's Vision 2020 states the country's commitment to "actively encourage science and technology education and ICT skills"
- Tanzania's Vision 2025 supports the "promotion of science and technology education."
- Uganda's National Development Plan outlines the country's goals to "construct laboratories for science and ICT as well as libraries to create a firm basis for acquisition of productive and employable knowledge and skills."

Multiple innovation drivers, outputs, and outcomes at play

A functioning innovation system depends upon the provision of quality math and science education, which is in turn, influenced by education policy and governance structures. There is no single policy prescription for the promotion of quality math and science education. The EAC Partner States share a number of priorities associated with secondary math and science education that drive system-wide reforms—increasing participation in math and science by girls, improving math and science teacher training, and introducing competency-based math and science education approaches. Efforts to mainstream math and science education at the secondary level, a policy driver observable across the EAC Partner States, appears to be achieving dividends in terms of encouraging female participation:

> *Because of [the change to make math and science courses compulsory for lower secondary education], we now have more girls taking science at a higher level. That's a really positive issue as far as policy is concerned. Before that, the girls really shunned away from science. Even at university, we're seeing the change. That's something we're*

proud of (Commissioner and Principal Education Officer, Private Secondary Schools, Ministry of Education and Sports, Uganda).

Another regional policy driver is the introduction of competency-based math and science curricula and examinations with the goal of emphasizing the real-world application of the course material. Uganda emphasizes the "vocationalization" of education, which endeavors to introduce more practical skills and knowledge into the secondary math and science curriculum (Secretary, Education Service Commission, Uganda). Similarly, Tanzania introduced competency-based curricula in 2005 with the goal of reorienting math and science education to promote practical knowledge (Education Officer, Department of Secondary Education, Ministry of Education and Vocational Training, Tanzania).

Research also revealed distinct perspectives on how support for secondary math and science education is realized through policy, as informed by national interests, culture, and resources. Two important drivers articulated in Rwanda's Education Strategic Plan include integrating ICT and entrepreneurship into secondary education (see textbox).

A unique driver of change in math and science education in Rwanda is the switch from French to English as the language of instruction. While the government maintains the change was necessary to bring Rwanda into alignment with international standards, interview respondents expressed concern that the instantaneous nature of the change would negatively impact student performance and comprehension. Other national levers of change to math and science secondary education include Uganda's National Science, Technology, and Innovation Policy and the 2005 Science Education Policy, Kenya's push to integrate notions of integrity and accountability into the teacher training system, and Burundi's important steps toward policy reform that include bringing private schools into compliance with national admittance standards. In Burundi, the education system still bears the scars of years of conflict, a reality the regional harmonization dialogue must take into account. Nevertheless, awareness of the need to change and modernize Burundi's education system was noted repeatedly as an essential ingredient for success in system reform and harmonization.

Box 2: Drivers of Education Policy Reform in Rwanda: ICT and Entrepreneurship

Rwanda's Education Strategic Plan 2010-2015 approaches ICT as a priority through six strategic areas:

(1) promoting an ICT in education culture;
(2) fostering and managing ICT in education initiatives through build[ing] and strengthen[ing] partnerships between different stakeholders and encourag[ing] participation of local institutions in ICT;
(3) expanding ICT infrastructure;
(4) developing capacity to integrate the use of ICT into education practices;
(5) developing and distributing quality digital content and ensuring that this content is adapted to the Rwandan context and aligned with the national curriculum; and
(6) establishing Open, Distance and e-Learning.

Entrepreneurship training is another priority of Rwanda's Education Strategic Plan 2010-2015. An entrepreneurship curriculum developed by the National Curriculum Development Center in 2008 focuses on four modules:

(1) commerce
(2) taxation
(3) accounting
(4) project development and management

Assuring quality effectively is an ongoing challenge

In each of the EAC Partner States, quality control mechanisms exist to monitor the effectiveness with which national policies are translated into learning outcomes. These include processes to align curriculum and examination content, monitor school-based performance through inspections, and offer pre- and in-service teacher training. Uganda, for example, requires annual school visits by the Ministry of Education and Sports.

While these mechanisms are in place, many stakeholders question their effectiveness. Respondents pointed to low passage rates on math and science exams, different standards for private and government schools, and the paucity of teacher evaluations conducted as evidence of quality assurance loopholes. Growing enrollment rates, the mushrooming of schools that require monitoring, and the scarcity of quality math and science teachers weaken efforts to assure quality. According to one interviewee from Rwanda, "The government and inspectorate are there to monitor appropriate standards. But in actual terms, there's not a lot to go by" *(Principal, Riviera Secondary School, Rwanda).* This characterization could well apply to other countries as well.

Grappling with quality assurance, respondents in every EAC country offered examples of efforts to enhance quality and efficiency. Decentralizing aspects of secondary education systems merited mention by Kenyan and Tanzanian interviewees, where the governments are introducing a more decentralized resource allocation process. Also, Rwanda is encouraging district-level officials to have a greater role in school inspection and accountability. By empowering actors working on the ground, governments may be freed from unnecessary administrative overhead, creating greater efficiency and ownership in the system. On the other hand, decentralization can render quality control even more difficult by weakening government's oversight into school-level activities.

Questions of influence, accountability, & contribution to planning persist

Top-down planning processes for secondary math and science education generally characterize the EAC Partner States, raising questions of participation within and ownership of education policy on behalf of teachers, industry, the science community, as well as the tertiary education sector. Even as various countries pilot decentralization efforts, the locus of governance and planning, especially the development of secondary math and science curricula and examinations, remains with the central government. Stakeholders from across the five countries expressed the need for greater participation by schools particularly in the planning process.

Balancing central control with decentralized implementation requires coordination, with the responsibility of actualizing policy falling to schools and teachers. An inherent tension exists in this reality, as schools and teachers are asked to take responsibility for secondary math and science education plans that too often feel exogenous to their efforts and ideas. Frequently, teachers reported feeling inadequately resourced for the job of implementation. According to one teacher in Uganda speaking to the top-down model of curriculum design, "We just teach what is passed on to us. We teach what has been shoved down our throats" (Head teacher, Luzira Secondary School, Uganda). Other critical voices, such as those from the private sector and scientific community, are largely missing or marginalized in the planning process as well, resulting in systems that struggle to achieve learning outcomes. "We should involve the consumers; involve the industry a little more, because they should tell us what kind of students they want" (Head, Computer Studies Department, Kenya Technical Teachers College).

Despite the marginalization of non-governmental voices, a few noteworthy steps across the region are being taken to inject a broader perspective into secondary math and science education policy-setting. During Tanzania's latest math and science curriculum review in 2005, for example, feedback was solicited from private sector entities, teachers, school administrators, non-profit organizations, and the scientific community through focus groups, interviews, and questionnaires. Similar efforts have been undertaken by the Uganda

National Curriculum Development Center. Even so, questions of *who* was tapped to participate remain.

Considerations for regional cooperation and questions for further discussion

In advance of the regional strategic dialogue on harmonizing secondary math and science education, readers are invited to consider the following questions regarding Pillar One as fodder for thought and future discussion.

- What national policy drivers should be integrated into a regional harmonization agenda? Which should be considered highest priority?
- How might quality assurance mechanisms for secondary math and science education be enhanced? What are regional best practices?
- What national/regional mechanisms for stakeholder engagement--existing or yet to be implemented--are needed to achieve systematic inclusion of voices (e.g., those of industry leaders, the scientific community, teachers, students, community groups, and school administrators) in regional planning and implementation processes?

"Talking about learner-centeredness and curriculum… I do not think there is a clear intention at this moment. The learner-centeredness is encouraged in the classroom situation, but it does not make sense if the curriculum and examination are focused on the memorization of contents."

--Project Coordinator, SMASSE Project, Ministry of Education, Rwanda

Pillar Two: Curricular Content

Key M&S secondary education curricular content trends at the EAC regional level:

- ***The EAC region is moving toward competency-based alternatives***
- ***Tensions exist between competency-based approaches and curricular features***
- ***Private sector not satisfied with outcomes, but hungry to help***
- ***Barriers to curricular implementation impede progress***

The EAC region is moving toward competency-based alternatives

Competency-based approaches to math and science education seek to achieve enhanced results by exposing students to practical applications of theory through hands-on, experiential learning opportunities. Whether by manipulating a pulley during a physics experiment or computing the answer to a math-based word problem, competency-based, participatory instruction moves students beyond rote memorization to problem-solving and comprehension sufficient enough to apply learning to real-world challenges.

Box 3: Curricular Content Definitions

- **Learner-centered education**: Teachers allow students to learn in a more experiential, hands-on manner, characterized by more open communication and a less rigid course structure. Teachers act as *facilitators*, rather than *instructors*.
- **Teacher-centered education**: Teachers play a crucial role in passing information along to students through lectures, exercising a high degree of control over the classroom and the direction of the student learning process.
- **Competency-based instruction:** Epitomizes a learner-centered approach, emphasizing outcomes that result in knowledge and skills applicable in real-world contexts.
- **Inquiry-based education:** Focuses on fostering the intellectual curiosity of students by allowing them to create conceptual frameworks for content based on their own experiences and use of problem-solving methods.
- **Participatory methods**: Teaching approaches that "put the student at the centre of the educational process … allowing him/her to express him/herself as much as possible…[and] help the student acquire a certain autonomy." (Pedagogical Management, Rwanda, 2011)

Understanding the positive impact competency-based math and science instruction can have on improving student learning outcomes, several EAC Partner States integrate such approaches in their classrooms, albeit with varying degrees of scope and success. In 2005, Tanzania introduced a revised math and science curriculum that identified the competencies students should have once a topic is covered. Through this new approach, "you have to teach both the theory and the practical together for the student to translate the theoretical *into* the practical" (Principal Education Officer, Department of Secondary Education, Ministry of Education and Vocational Training, Tanzania). Similarly, UNESCO supported a competency-based curriculum review in Burundi beginning in 2004 to replace the one written in 1989. In lieu of a comprehensive implementation of the new curriculum, the Bureau of Studies and Secondary Education Curriculum Development (BEPES) undertakes small-scale elaborations of the curriculum to introduce competency-based aspects.

The Uganda National Academy of Science supports the introduction of inquiry-based science education into the Uganda secondary education system, which "stresses the innovative use of simple methods and resources to teach science, even in the absence of more traditional resources" (President, Uganda National Academy of Sciences). A comprehensive curricular review has not been undertaken since 1982, though one is planned for the lower secondary level, according to the National Curriculum Development Centre. "The new curriculum will help learners make informed decisions as citizens and family members, and it will give those who continue with their education, either immediately in S5 or later in life, the skills they need to think critically and study efficiently" (Uganda National Development Plan, 2010).

Each EAC country asks its students to satisfy different requirements in math and science courses, highlighting the diversity of Partner States' organization of their math and science curricula, as shown in the table below.

Box 4: Math and Science Course Requirements of EAC Partner States at Secondary Level

Country	Level	Math & Science Course Requirements
Burundi	Lower secondary (4 years)	• Lower secondary: math and science required
	Upper secondary / College (3 years)	• Upper secondary: optional two subject combinations available include Scientific A (Math and Physics) or Scientific B (Biology and Chemistry)
Kenya	Secondary (4 years)	• All four years: math compulsory • First two years: biology, chemistry, physics compulsory • Last two years: select two-subject science combinations
Rwanda	Lower secondary / O-level (3 years)	• First three years: math, biology, chemistry, and physics required
	Upper secondary / A-level (3 years)	• Last three years: select three-subject science combinations • Entrepreneurship training
Tanzania	Lower secondary / O-level (4 years)	• First two years: chemistry and physics compulsory
	Upper secondary / A-level (2 years)	• First four years: math and biology compulsory • Upper secondary (2 years): select three-subject combinations that may be science-based
Uganda	Lower secondary / O-level (4 years)	• First four years: math, biology, chemistry, and physics compulsory
	Upper secondary / A-level (2 years)	• Last two years: select four-subject combinations

As competency-based approaches take root in the East Africa region, consideration must be given as to how course requirements and curricular content will or should change too. Further, efforts to harmonize curriculum across the Partner States must take into account national investments in and/or plans for curriculum reform, as such processes require a great amount of investment in terms of time and resources.

Tensions exist between competency-based approaches & curricular features

While competency-based, participatory approaches out-perform "teach to the test" methods, they may also require greater investments of time, resources, and teacher training to ensure practitioners gain fluency in both content and pedagogy. As a result, there is a tension between competency-based reforms and existing curricular content features. The following quote from an interview respondent provides insight into a critique common across the EAC Partner States:

> *Talking about learner-centeredness and curriculum…I do not think there is a clear intention at this moment. The learner-centeredness is encouraged in the classroom situation, but it does not make sense if the curriculum and examination are focused on*

the memorization of contents (Project Coordinator, SMASSE Project, Ministry of Education, Rwanda).

Interviewees' concerns underscore the failure to realize the potential of competency-based approaches in the provision of secondary math and science education. Respondents shared concern over the lack of measures taken to avail teachers of the time or training required to deploy these new approaches successfully or consistently. Reconciling the introduction of competency-based alternatives with existing curricular features is an ongoing challenge for the EAC Partner States, and one that needs significant attention.

Insights from country level include Burundi's struggle to operationalize changes to the curriculum. Interviewed sources reported that the curriculum documents "give only titles, not the material…they don't give methodologies, [or] any indication on evaluation." (Advisor to the Cabinet, Ministry of Education, Burundi). In Tanzania, critics suggest the updated curriculum "is the same old syllabus with competencies inserted in there as an extra column" (Education Consultant, Tanzania). Rwanda offers a positive example. Recently, Government took efforts to modify its system to be more amenable to learner-centered approaches. It exerted effort to streamline the math and science requirements by cutting the required papers from 8 to 2 in 2008/2009, thereby relieving some of the "teach to the test" pressure. This change allows teachers and students to delve more deeply into fewer subjects.

Private sector not satisfied with outcomes, but keen to help

While countries are making strides to incorporate more practical aspects of math and science into the secondary education process, the curriculum remains largely theoretical, without focus on real-world problem solving. Many respondents from the private sector pointed to this fact, stating that their education systems seldom provide students with the key math and science skills necessary for employment:

> *The curriculum at all levels is not aligned to the needs of industry, and should be updated to be more practical and applicable to real life than the theoretical focus that currently exists* (Programme Officer, Kenya Private Sector Alliance).

In an effort to improve the alignment of secondary math and science curriculum with labor market needs, national governments and private sector entities are exploring new avenues of collaboration. Several representatives of the private sector and the scientific community expressed consistent support for opportunities to formally engage in curriculum design, review, and reform processes. According to one representative of the Uganda Manufacturers Association, among all of the initiatives underway, their highest priority is to improve linkages between the educational and industrial sectors. However, the lack of formal mechanisms to do so stymies their ability. Noteworthy strides to increase the voice of private sector and the scientific community in the curriculum development and review processes emerged through field interviews. Rwanda's Private Sector Federation, for example, undertook a labor market profile and developed a preliminary qualifications framework for critical sectors. The Rwandan government and the Private Sector Federation agreed to build upon this initiative with a more comprehensive labor market survey. Finally, in Kenya, subject-matter experts plan and review curriculum. Organized into panels of seven members, which include employers and other stakeholders, the panels determine the contents, the instructional time, and even assist in writing syllabi. The National Council for Science and Technology participates in the panels and generally thinks its advice is heeded thanks to the participation of "eminent scientists from universities and the private sector" (Chief Science Secretary, Kenya National Council for Science and Technology).

While these two case studies offer examples of how government-industry-academia cooperation on curriculum development might take shape, hunger for enhanced opportunities for interaction emerged repeatedly in stakeholder interviews. Institutionalized mechanisms to incorporate the advice and needs of industry are especially warranted as the Partner States make strides toward ensuring secondary math and science education succeeds in delivering not only job-seekers but also job-creators. The curriculum review process used by Tanzania's Technical and Vocational Education and Training (TVET) institutions offers a potential mechanism to formalize the role for private sector and the scientific community in the secondary math and science curriculum development process (see textbox).

Box 5: TVET Curriculum Review Process in Tanzania

- Coordinated by the National Council for Technical Education (NACTE)
- Focuses on situational analysis, which incorporates employer needs, professional needs, societal needs, feedback from graduates, staff, and external assessors.
- Encompasses a wide variety of industries, so NACTE created boards responsible for specific areas: (1) agriculture and environment; (2) business and marketing; (3) engineering and other sciences; (4) health and allied sciences; and (5) planning.
- Each board meets at least 5 times per year and includes representatives from key stakeholders, including non-governmental organizations, employers, government, universities, technical schools, and professional bodies in those industries.
- Committees of subject-matter experts appointed by the boards review the curriculum and recommend changes to the board.
- Technical schools use recommendations of boards to revise their curriculum per the procedure outlined by NACTE, which approves and validates the new curriculum upon submission.

Barriers to curricular implementation impede progress

Curricular content, as with the other pillars of secondary math and science education put forward for discussion in this paper, does not exist in isolation. As explored in the introduction, each of the pillars interacts with the others in a dynamic system. The positive changes made to math and science curriculum can only be realized in so far as implementation occurs: "The success of the curriculum depends very much on its implementation and on teachers as the implementation agents…That is where we might have a problem" (Director, Kenya Institute of Education).

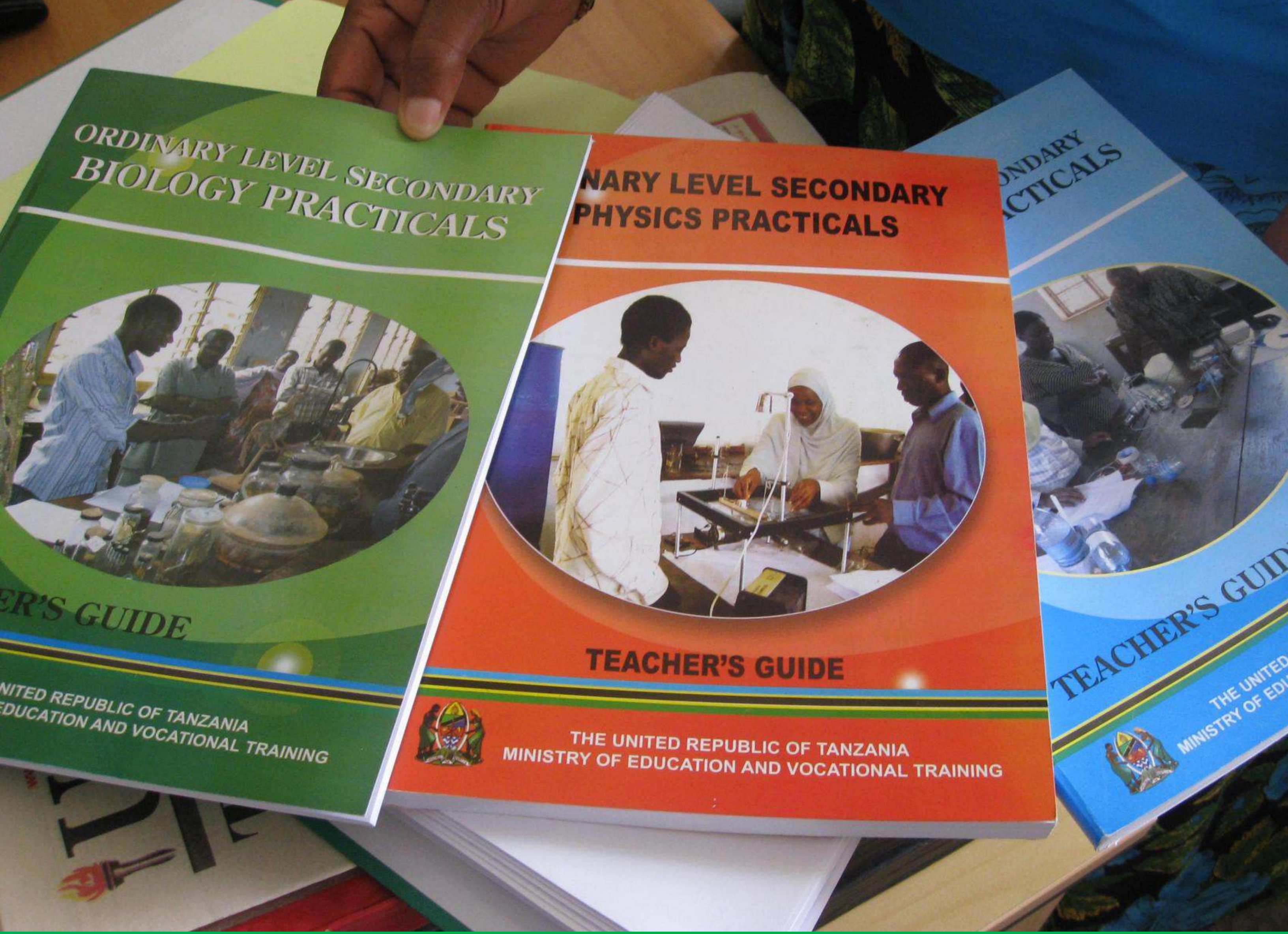
Consistently, interviewees pointed to barriers hindering the implementation of math and science curriculum at the secondary level. These include inadequate teaching and learning resources and infrastructure to support utilization of hands-on learning approaches, insufficient teacher training on new curriculum features and expectations, and a resultant lack of student interest in pursuing math and science education. Without addressing these and other barriers to implementation, even the most well-aligned, learner-centered curriculum will not trigger improved learning outcomes.

Implementation barriers pertaining to other pillars will be explored in further detail in follow-on sections. It is important to note here, however, that the EAC Partner States keenly recognize the disconnect between policy and the intended curriculum on the one hand, and classroom experience on the other. The gap generated by this disconnect impedes performance. In most cases, national governments are taking an active role in addressing the implementation barriers outlined above. Interview respondents noted with enthusiasm the role that regional harmonization might play in helping countries learn from one another, given many of the opportunities and challenges they face are similar in nature.

Considerations for regional cooperation and questions for further discussion

In advance of the regional strategic dialogue on harmonizing secondary math and science education, readers are invited to consider the following questions regarding Pillar Two as fodder for thought and future discussion.

- How might regional harmonization help provide a pathway for integration of hands-on, participatory approaches to math and science education at secondary level?
- What steps are needed to reconcile regional curriculum harmonization with national curriculum reform plans and investments?
- What are the most critical barriers to curriculum implementation common among the five Partner States? How might harmonization help overcome them?



"If you go to a school with plenty of resources, the perception [of math and science] is very positive. If you go to the rural areas, the teaching of those courses is very abstract and students find it hard to understand the concepts they are being taught."

--Lecturer, Education Foundation and Policy,
Kenyatta University, Kenya

Pillar Three: Teaching and Learning Resources

Key secondary M&S teaching and learning resources trends at the EAC regional level:

- ***Premium on understanding the backdrop of teaching and learning resource needs***
- ***Resources defined as essential vary across EAC Partner States***
- ***For resources in use, place and access matter***
- ***Interesting opportunities for sharing resources exist in the region***

Premium on understanding the backdrop of teaching and learning resource needs

Teaching and learning resources are supplemental tools used by teachers and learners to augment traditional lecture-based instruction methods with those that are more dynamic, hands-on, and participatory. Examples include textbooks, science kits, laboratory equipment and consumables, demonstration devices, and information and communication technologies (ICTs). Competency-based approaches to math and science education emphasize the use of teaching and learning resources as essential tools to explore the practical applications of concepts rather than just the theory behind them.

Before a discussion about teaching and learning resources can take place, one must confront the fact that without basic infrastructure, the benefits of such resources cannot be fully realized. Indeed, against a backdrop of schools without desks or consistent electricity, discussions of integrating ICTs into classrooms, for example, may be premature. This is especially the case in systems across the EAC where enrollments at secondary level are booming, stretching an already lean resource base.

Where teaching and learning resources are available, interviewees resoundingly agree that their integration into the classroom positively impacts both student perceptions of math and science as well as their learning outcomes.

> *If you go to a school with plenty of resources, the perception [of math and science] is very positive. If you go to the rural areas, the teaching of those courses is very abstract and students find it hard to understand the concepts they are being taught* (Lecturer, Education Foundation and Policy, Kenyatta University).

At country-level, interviewees noted rural electrification programs in Uganda and Kenya as positive government investments essential to schools' ability to deliver quality education. In Burundi, support for investment in an optical fiber system to expand the availability of ICTs also earned mention. Further, Kenya's Constituencies Development Fund, a publicly-funded organization targeting grassroots development projects, provides a novel mechanism for constructing the new schools needed to contend with growing enrollment rates. Funds from the CDF are devolved directly to the local level, emphasizing decentralization of decision-making. CDF boasts about 60,000 projects throughout the country since its inception in 2003, almost half of which (46.2%) relate to education (Government of Kenya, 2011).

Resources defined as essential vary across EAC Partner States

When considering the role that regional harmonization might play in addressing teaching and learning resource needs, it is important to ask - what teaching and learning resources do the EAC Partner States construe as essential for ensuring desired learning outcomes in secondary math and science education?   Research reveals diverse minimum standards that EAC Partner States aspire to uphold. For example, Kenya requires that every registered school have at least one laboratory. Availability and use of text books remains highly restricted. While numbers vary, interview respondents consistently pointed to textbooks, laboratory equipment, science kits (where in use), and ICTs as critical, if not essential, teaching and learning resources for secondary math and science education.

For those resources deemed essential, Partner States actively engage in efforts to enhance their availability. For example, Rwanda's textbook procurement scheme strives to accommodate the change of instructional language from French to English. Separately, Kenya's CDF allows for the purchase of necessary laboratory equipment in addition to financing school construction, as mentioned previously. However, limited financial resources constrain supply.

For resources in use, their location and access matter

Even as interviewees noted severe resource gaps, they pointed out a number of teaching and learning resources in use regionally. Schools in each of the Partner States use textbooks and laboratory equipment, though utilization is dramatically impacted by supply constraints. Both Tanzanian and Ugandan respondents indicated the availability of science kits while ICTs received mention in all EAC Partner States. Undermining the impact of these resources in terms of enhanced learning outcomes is the relative scarcity of training programs needed to foment teachers' ability to wield them effectively. Quite divergent among respondents, too, is the degree to which these resources are available and in use across the five Partner States, within the countries (e.g., rural versus urban), and even among schools within close proximity of one another (public versus private, communal or "ward" versus traditional). Interviewees noted the common but severe disparity between resources available to schools within urban centers and those located "up-country." According to one Ugandan respondent, "The few [schools] that have these resources – science kits, lab equipment, ICTs – are those around Kampala. The bigger part of the country is really suffering" (Director of Policy and Policy Officer, Private Sector Foundation). A similar rural/urban divide characterizes the uneven spread of resources in the other EAC Partner States.

Where teaching and learning resources are available, utilization may be minimal for fear of damage or theft. Interviewees pointed to practices of locking up textbooks and not using laboratory equipment out of concern the students might damage them. Ensuring teachers are comfortable with and able to use the resources effectively is another factor critical to their effectiveness, as noted by an interviewee in Tanzania.

> *Having materials is one thing … actually utilizing them is another thing…It is a matter of the teachers helping the students. If they could do this, the outcome would not just be good, it would be very great* (Mass Communicator, Tanzania Higher Learning Institutes Student Organization).

Numerous examples of EAC stakeholders' unique approaches to using local resources to overcome supply problems highlight the creativity that clever and committed teachers can bring to the classroom. For example, the Ministry of Education and Vocational Training in Tanzania developed a guide that shows teachers how they can use "locally available materials," such as iron wool, empty water bottles, and bleach to perform scientific experiments and demonstrations. Similarly, in Burundi, resource shortages triggered a novel initiative in which students borrow books from other students and teachers borrow

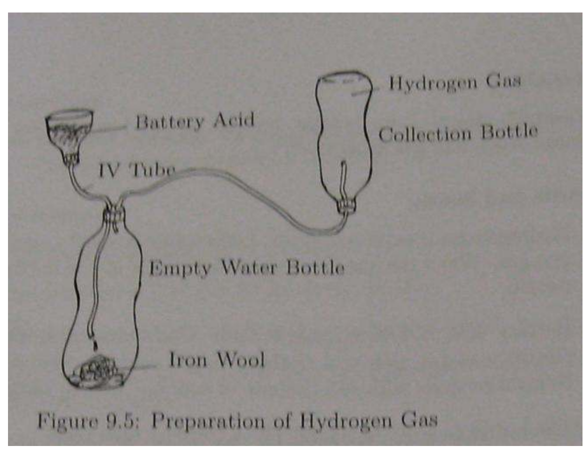


Figure A. Excerpt from a Teacher Guide Demonstrating use of Local Materials, Tanzania instructional materials from other teachers. Such actions have resulted in an educational "economy of solidarity" that "is a different philosophy of life which cannot be financially measured" (President of Parent's Committee, Lycée du Saint-Espirit Secondary School, Burundi).

Interesting opportunities for sharing exist in the region

Various Partner States appear to use distinct approaches to resource procurement, distribution, and maximization. Uganda, for example, established "centers of excellence", sometimes two per district, where resources are concentrated such that other area schools may access them. The Tanzania Education Authority (TEA) aims to fill gaps in teaching and learning resources provided by the Ministry of Education and Vocational Training by accepting applications from schools and allocating resources per requests. Interviewees noted, however, that request responses are often slow to come, and TEA fails to provide laboratory consumables. Filling this gap, a system was established for communities to contribute funds to buy perishable items for school laboratories (Allocation Officer and Education Manager, Tanzania Education Authority).

ICT-based options such as computer-based simulations and digitized content are beginning to offer attractive alternatives to traditional teaching and learning resources such as laboratory equipment and textbooks. As governments consider such options, projects that utilize ICTs crop up. Burundi's Commission on ICT identifies ICT-based equipment such as laptops for schools and considers how to integrate such resources into secondary school curriculum. Tanzania Beyond Tomorrow, an e-learning project started in 2010, strives to extend educational opportunities in rural areas through distance learning. With partners such as NetHope, Accenture, Microsoft, Cisco Systems, and Intel, the project seeks to enhance learning for 1.5 million students in 4000 secondary schools. Because of the lack of infrastructure in the rural areas for internet-capability, the project includes plans for solar-powered electrical systems and new fiber optic cables to bring the Internet to schools currently without connectivity (E-learning Africa, 2010). In Uganda, CyberScience, a digital science and virtual lab software from Cyber School Technology Solutions, brings the excitement of beating hearts and photosynthesis as animated on a computer screen into the classroom. "Cyber Science is so popular in my school. Students will run to the lessons!" explained one head teacher (Head Teacher, Luzira Secondary School, Uganda).

The diversity of these programs points to the different ways ICTs enhance student learning in math and science. As governments continue to test these alternatives the question of sustainability remains. Interviewees noted that such investments often remain ad hoc projects, without becoming institutionalized into broader education efforts. This critique applies as well to other country-based resource projects explored below.

Among the country-based approaches adopted to enhance secondary math and science education, a number of EAC Partner States engage the private sector as a resource. The Private Sector Federation of Rwanda, for example, designed a program in which approximately 200 students gain access to companies' equipment for learning and practice. Separately, the Uganda Manufacturer's Association advocates for student placements in internships and involves students in trade fairs to give them exposure to opportunities in industry.

Interviewed respondents also pointed to science clubs and competitions as novel resources promoting enhanced learning outcomes in and perceptions of math and science. UNESCO Science Clubs, which are active in Burundi and Tanzania, provide an outlet for students to share knowledge and participate in visits to math and science-based institutions outside their school. In Kenya, a popular resource for secondary math and science students is the Science Congress, an annual nation-wide competition in which students showcase their scientific knowledge through a series of science fairs that start at the district level and build to the national level. Science Congress receives support from the Ministry of Education and the Kenya National Academy of Sciences.

Considerations for regional cooperation and questions for further discussion

In advance of the regional strategic dialogue on harmonizing secondary math and science education, readers are invited to consider the following questions regarding Pillar Three as fodder for thought and future discussion.

- How might regional harmonization serve as a vehicle to establish minimum thresholds for those resources defined by Partner States as essential for math and science instruction at secondary level?
- How might creative approaches to maximizing available resources and overcoming gaps be shared and sustained through regional collaboration?
- What actions at regional level would help ensure those teaching and learning resources available are being optimally used to promote student learning?
- Can the region benefit through economies of scale if learning resources such as textbooks are harmonized?

"The policy is learner-centered teaching. There is one challenge – the teachers trained in content-based are [expected to teach] in the learner-center approach with no retraining. They have not been reoriented in the new approach."

--Secretary General, Association of Managers and Owners of Non-Governmental Schools and Colleges, Tanzania

Pillar Four: Teacher Training, Professional Development, and Pedagogy

Key secondary M&S teacher training, professional development, and pedagogy trends at the EAC regional level:

- ***Distinct and diverse pathways exist that lead toward becoming a secondary math and science teacher across the EAC Partner States***
- ***Different approaches to recruiting secondary math and science teachers prevail***
- ***Retaining secondary math and science teachers a consistent challenge***
- ***Excellence fostered through enhanced pedagogical training***

Distinct and diverse pathways exist that lead toward becoming a secondary math and science teacher across the EAC Partner States

EAC Partner States offer diverse and distinct pathways to becoming a secondary math and science teacher. Some pathways involve exposure to content and pedagogy, some only to content. Some require internships and in-school training, while others are limited to class-based exposure. Unclear from these options is what constitutes the *optimal* pathway for secondary math and science teacher training. Lack of clarity as to what type of training is necessary to ensure secondary math and science teachers exit their preparation phase with the skills and knowledge necessary to do the job set before them comes at a price: "competencies expected of teachers are extremely low" (Officer, Teacher Education Department, Ministry of Education and Vocational Training, Tanzania). Case studies from Kenya and Rwanda follow to serve the point.

In Rwanda, to become a lower secondary school teacher, a secondary school completer must enter a College of Education for two years and obtain a Diploma. Teaching at upper secondary school requires completion of a four-year degree at the Kigali Institute of Education. Government aims to coordinate all teacher education and qualification with the 2010 Education Sector Strategic Plan that states, "A teacher professional pathway will be implemented with the long-term goal of establishing teaching as a graduate profession" (Rwanda Education Sector Strategic Plan, 2010). The Plan also states that a qualification framework for teaching will be developed by 2015.

In Kenya, three main pathways offer entrance into the secondary math and science teaching profession.

(1) Obtain a three-year diploma, for which a student must have a C average upon completing secondary school and must pass the two subjects (math/chemistry, physics/biology) that he/she will teach in secondary school. Diploma candidates are required to conduct in-school training in their third year.

(2) Complete a four-year Bachelor of Education degree, for which a student must have a C+ average upon completing secondary school. Degree candidates complete a three-month teaching internship in their fourth year.

(3) Obtain a four-year Bachelor of Science degree, which does not expose future teachers to pedagogical training. Pedagogical training may be attained through admission into an under-utilized post-graduate degree program in teaching.

Regardless of which track better prepares future teachers for the rigors of teaching, supply constraints render countless schools willing to hire untrained teachers in math and science to fill gaps. Either because qualified teachers are unavailable or too expensive, the unpaved track by which untrained individuals serve as trainers for future generations jeopardizes educational quality standards and outcomes.

Different approaches to recruiting secondary math and science teachers prevail

Across the region, interviewees pointed to imbalances in the supply of and demand for quality math and science teachers. This reality impacts the approaches countries take toward recruitment. Regionally endemic shortages of secondary math and science teachers appear to be even more acute in rural or "up-country" locales, as noted by respondents:

> *The big problem comes, since there are few [secondary math and science teachers] and in high demand, they are concentrated in urban areas where they can get employment and other social services. You go to remote areas, and you won't find them* (Officer, Teacher Education Department, Ministry of Education and Vocational Training, Tanzania).

By contrast, Kenya faces a variation of the supply-demand problem:

> *As we speak now, there is no shortage [of secondary math and science teachers], but funds are not available to bring them on board. Manpower does exist, but funds do not* (Assistant Director, Post-Primary Staffing, Teachers Service Commission).

This unique feature of the Kenyan education system may have implications for regional harmonization in terms of mobility of Kenyan teachers throughout the region.

As with teacher training, the EAC Partner States take a number of approaches to teacher recruitment and placement within their systems. In Kenya and Burundi, for example, one approach to teacher recruitment is more decentralized such that schools and districts articulate their needs and hire accordingly. Uganda uses a centralized recruitment and placement process. Challenges to do with geographic placement contributed toward Burundi's and Kenya's decision in favor of a more decentralized recruitment process. In Burundi specifically, such efforts target local graduates in rural areas in an attempt to slow teacher turn-over rates.

Retaining secondary math and science teachers a consistent challenge

Upon completion of training and successful placement into a school, teacher retention poses the next challenge with which government must contend. Chipping away at Partner States' achievements toward teacher retention are a number of perceptual challenges marring the attractiveness of the teaching profession. One Headmaster's quote paints the picture.

> *In Uganda, teaching is rarely the first choice for any teacher. Those who become science teachers are dreaming of being engineers, and when they don't get what they want they move to the next option…being a science teacher in Uganda is often almost an accident* (Headmaster, King's College Budo).

Common disincentives to teaching include poor salary, heavy workload due to large class sizes and demanding course requirements, perception of the difficulty of math and science, and the lack of teaching and learning resources. The vicious cycle of low perceptions and hastening rates of teacher turnover creates additional pressure on governments to fill positions and expedite training, perhaps at the expense of quality.

Various countries' achievements toward mitigating teacher turnover bear exploration. In Burundi, BEPES sometimes facilitates the provision of housing and organization of transport in rural districts. Similarly, the Kenyan government provides additional—though few and dwindling—incentives for those locales it deems as "hardship" placements. Finally, Tanzania prioritizes math and science in hiring teachers, and offers guaranteed loans to students who pursue higher degrees in math and science, including in teaching.

However, loopholes compromise the incentive structure: "Going to a teacher's career is a way of getting a loan. Once someone gets a loan and completes their degree, they have remaining money [with which they can] get an MBA then work as a marketing manager for a telephone company or a bank" (*Secretary General, Association of Managers and Owners of Non-Governmental Schools and Colleges, Tanzania).* What is clear from these and other examples is EAC Partner States' willingness to explore the use of incentives to promote teacher retention, satisfaction, and a sense of professional worth.

> *"We come on board this business as a matter of accident. We never planned to become teachers; we had different dreams. We fight for our dreams. The dreams never come true. We are forced by circumstances. We board this bus because it is the only bus with seats."*
>
> *Teacher, Paradigms Secondary School, Tanzania*

Excellence fostered through enhanced pedagogical training

Whatever content mastery teachers gain through their training, their preparation appears to systematically underemphasize math and science pedagogy. The result is a population of teachers often unprepared to implement the new competency-based, participatory curricula promoted regionally.

> *The policy is learner-centered teaching. There is one challenge – the teachers trained in content-based are [expected to teach] in the learner-center approach with no retraining. They have not been reoriented in the new approach* (Secretary General, Association of Managers and Owners of Non-Governmental Schools and Colleges, Tanzania).

A consistently-cited intervention that enhances teachers' pedagogical capability is that of the Japanese International Cooperation Agency (JICA). In cooperation with national governments, JICA sponsors a number of innovative in-service teacher training programs in math and science in the region. While these trainings earn region-wide praise (as evidenced by interviewees' feedback), respondents in Uganda and Kenya noted the ad-hoc nature of the trainings and expressed a desire for further institutionalization of pedagogical training nationally or even regionally. Further, country-based differences point to how small changes to incentives and structure may influence the impact of such opportunities. For example, in Kenya, in-service trainings are compulsory, resulting in participants' sentiment that the skill-upgrading is imposed (Director, CEMASTEA). By contrast, SESEMAT programs in Uganda are voluntary, and rewarded with a certificate of completion that participants consider instrumental for career advancement (Senior Education Officer, Ministry of Education and Sports, Uganda). See textbox 6 for further details.

Enhancements in the teaching of math and science at the secondary level depend to a great extent on sustaining a cohort of teachers who regularly upgrade their math and science skills and knowledge. Teacher training colleges and in-service training programs in Kenya, for example, seek to systematically introduce ICT-based training so that all teachers may be equipped to fully utilize the growing ICT resource base. As such, ICT is now a mandatory subject at the Kenya Technical Teachers College, which is equipped with approximately 500 computers for its 1000 students.

Box 6: Supporting In-Service Math and Science Teacher Training in East Africa – The JICA Case Study

Integral to the creation and support of teacher in-service education and training (INSET) programs in East Africa, JICA offers a number of programs in math and science pedagogy. One of the first and most successful is SMASSE – Strengthening of Mathematics and Science in Secondary Education. SMASSE began in 1998 as a pilot project in nine Kenyan districts as a response to a JICA-funded study showing a dire need in the country for improvement in math and science teaching.

The SMASSE approach to teacher training emphasizes learner-centered pedagogical techniques such as: **ASEI** (Activity, Student, Experiment, and Improvisation) and **PDSI** (Plan, Do, See, Improve). It also promotes innovative uses of local resources and hands-on instruction. Proven to be effective, in 2004, SMASSE became an international program with the establishment of SMASSE-WECSA (Western, Eastern, Central, Southern Africa). The Center for Mathematics, Science and Technology Education in Africa, or CEMASTEA, was founded by the Government of Kenya shortly after to serve as a regional hub for in-service teacher training and knowledge exchange. SMASSE-type programs have been implemented in other EAC countries as well, including the SESEMAT (Secondary Science and Mathematics Teachers') program in Uganda, which started in 2005.

Evidence of JICA's programs on quality of science and math teaching in the region is accumulating. In Kenya, physics enrollment for higher education institutions rose by 10% since the inception of SMASSE, which is in part attributed to the positive changes in attitude toward physics catalyzed by SMASSE.

Tanzania demonstrates a slightly different approach to enhancing the pedagogical skill base of its teaching professionals. There the government established a system of 410 Teacher Resource Centers designed to (1) improve teacher quality; (2) link teachers with continuing training from Teacher Training Colleges; and (3) provide teachers with advice, guidance, support, professional development, and information. A Teacher Resource Center Coalition empowers teachers by providing a common center to share information, strategies, and skills among the hundreds of national Centers in the network.

Considerations for regional cooperation and questions for further discussion

In advance of the regional strategic dialogue on harmonizing secondary math and science education, readers are invited to consider the following questions regarding Pillar Four as fodder for thought and future discussion.

- What is the optimal pathway to becoming a secondary math and science teacher?
- What minimum teacher training requirements should be upheld at both national and regional level? For example, should in-school training / internships be required for all teaching candidates?
- What factors must be addressed to improve both recruitment and retention of quality secondary math and science teachers?
- What are regional best practices in pedagogical training for secondary math and science teachers? How might such best practices be shared and scaled?

"The curriculum is more academic as opposed to work-oriented. Most of the curriculum does not address income-making skills. I think that the heavy focus on the aspirations of educators to put the students into higher education is too much."

--Principal Education Officer, Ministry of Community Development, Gender and Children, Tanzania

Pillar Five: Evaluation of Learning Outcomes

Key trends in evaluation of secondary M&S learning outcomes at the EAC regional level:

- ***Evaluation processes dominated by centrally-administered exams***
- ***Negative perceptions of math and science skew student interest***
- ***Preparation at secondary level geared for higher education, not employment***
- ***Poor alignment within system diminishes math and science learning outcomes***

Evaluation processes dominated by centrally-administered exams

"Examination results in Africa are high stakes. They have been and still are the dominant assessment factor for education in Sub-Saharan Africa. They hold great significance as a rite of passage, thereby providing incentives and motivation for students to learn," noted a 2008 SEIA World Bank study. Indeed, interviewees repeatedly asserted that in the EAC, often what is not tested is not taught.

The impact of a student's performance on exams lingers long after the exam results are returned. Governments frequently make determinations regarding the direction of student learning from these exam results, which impact students' opportunities to continue into higher learning or entry into the world of work. In Burundi, for example, performance on the state exit exam from lower secondary determines whether students move to upper secondary and if they study math and science while there. The use of exams as an evaluation tool in itself is not a bad practice. Rather, it is the heavy dependence on this singular evaluation tool that creates exam-driven systems, which in-turn creates disincentives for secondary math and science teachers and students to explore creative learning opportunities. Exams are best used as part of a framework of evaluation designed to assess a student's full grasp of a subject, not just their memorization or test taking skills.

EAC Partner States strive to reconcile this tension by introducing practical assessments that test students on their knowledge of math and science-based applications. In such exam-dominated systems, changes in the evaluation process are needed to spur further integration of competency-based approaches. Uganda administers exams at the end of lower and upper secondary; in both instances those students with laboratory access are given practical papers in math, biology, physics, and chemistry. Results at this point are mixed:

> *National examinations in Uganda test both theoretical and practical knowledge in the sciences, although the practical components are not difficult and can be passed simply by following the instructions. Essentially, practical papers do not actually test practical knowledge. Teachers tend to teach to the exam as a result of this lack of need for critical thinking on the part of the students* (Principal Examinations Officer, National Assessment of Progress in Education, National Examinations Board, Uganda).

Rwanda too is reorienting its examination process to include practicals, both a central exam for O-level at the end of the third year of secondary, and another at the end of the final year of A-level.

As a corollary to national exams, use of continual assessment earned mention. Used in Tanzania and piloted in Uganda, continual assessment evaluates student performance over time, thereby offsetting the weight of the national exam. The extent to which education officials consider continual assessment against exam scores is not clear in cases where it is used. According to one Tanzanian interviewee, "Continual assessment is supposed to be 50% of the student's final grade, but in reality they do not really rely on the continual assessment" (Education Consultant, Tanzania). Large class sizes may hamper teachers' ability as well as reliance on continuous examination. Further, the linkage between assessment reform and teacher preparedness demands attention. If new examination formats are not integrated into teacher training they will not succeed in altering learning outcomes.

Negative perceptions of math and science skew student interest

Not surprisingly, a large percentage of students across the EAC find math and science more challenging than other subjects. Such sentiments echo those expressed by students in the US, Europe, and other regions of the world. What may be distinct to the EAC or Sub-Saharan Africa more broadly, however, is students' rationale for these feelings. Interviewed secondary students in the five Partner Countries offered a laundry list of reasons their interest in math and science is subdued. Among their observations (see text box), they cited limited exposure to practical exercises that allow science to unlock their imagination. They also stressed a perceived lack of employment opportunities in math and science-based careers. The extent to which those perceptions cause students to shy away from pursuing opportunities in math and science is problematic given the drought-effect this can have on the professional math and science human resources pipeline needed for the attainment of national development goals. Interviewees recommended improved career counseling and access to professional mentors as ways to enhance student knowledge of career options in math and science.

Box 7: In Their Own Words: Student Perceptions of Math and Science in Rwanda

We wish to be scientists but Rwanda is not so developed. We can't find work. We can go to university in biology but we can't find work. So we choose the career where we can find work (Students from Ecole Autonome Secondary School of Butare).

Science is possible for me because it is interesting. Science helps us to know the parts that make our bodies, how our bodies work: muscles, brains. It helps us to know the things surrounding us (Students from Elena Guerra Secondary School).

Development of our country impacts our perceptions….By being a scientist, I can contribute. Parents tell us to do it. That's a big factor. I think there are good paying jobs in math and science. With science, you get to create your own employment trajectory (Students from Riviera Secondary School).

Focused on improving student perceptions of math and science, EAC Partner States exhibit a number of reforms underway. In Rwanda, for example, government provides students who pursue math and science degrees at higher learning institutions with scholarships that pay 75% of their fees; students with high marks may receive scholarships covering 100% of fees. The prospect of free or highly-subsidized university education effectively lures students toward math and science-based studies. Competitions supported by the Tanzania Ministry of Communication, Science, and Technology that reward high achievers in math and science illustrate another intervention to increase excitement for and interest in these subjects (Principal Education Officer, Ministry of Communications, Science, and Technology).

Preparation at secondary level geared for higher education, not employment

Interviewed sources across the region clearly indicated that secondary school systems in the EAC orient students for higher learning more so than the world of work, epitomized by one Rwandan entrepreneurship expert:

> *I think most of these secondary schools' math and science subjects prepare students for higher education. It is difficult for them after they graduate from secondary school to go*

> *to the labor market to get a job because they lack the skills … you know the link between the science subjects and the community or the labor market--there is a gap there* (Entrepreneurship expert, Rwanda).

With so few secondary school leavers destined for tertiary education, many sources interviewed criticized the disproportionate focus placed on preparing students for higher learning. Interviews with such organizations as the Private Sector Federation of Rwanda and the Uganda Manufacturers Association detailed the degree to which this orientation is out of sync with national or regional industry. Simply put, secondary school graduates "are not equipped with the required practical skills to work" (Maintenance Engineer, Tanzama Pipeline, Tanzania).

Rather than merely voice their dissatisfaction, many private sector representatives from across the region expressed a commitment to changing the orientation of secondary math and science education. Questions of how best they can "plug in" to the educational process loom large, though. Additionally, interviewees confirmed a lack of widespread mechanisms to track the destination of students exiting secondary school, so data regarding their employment potential is scant at best. Similarly, although a number of interviewees recommended a "qualifications frameworks" to define what learning outcomes are expected of students accessing various professions, few national examples appear to exist. Rwanda's Private Sector Federation (PSF) offers one rare example. In partnership with the government, PSF seeks to complete a national skills audit, which will be used to inform curricular and evaluation processes. According to RPSF's Chairman, this initiative is "focusing on different sectors which respond to the needs of the labor market. We are trying to see - what are the booming sectors? What type of person do we need in construction? How can training providers respond to what is needed on the labor market?" As a key to unlocking greater labor market mobility, such a framework may constitute an essential ingredient for regional harmonization.

In Burundi, respondents asserted that technical secondary schools fair better at preparing students for employment, as the training is more aligned with the needs of the labor market. Further, students must complete an internship as part of their studies. According to the President of the Industrial Association of Burundi (IAB), plans are underway to "aggregate all companies registered in the IAB, identify their needs in terms of skills and competences in one database, and then cross check with technical schools and universities to locate those human resources according to the companies' needs" (President, Industrial Association of Burundi).

Poor alignment within system diminishes math and science learning outcomes

Multiple factors converge to impact the learning outcomes achieved by secondary math and science students in the EAC. Not only does the evaluation process impact these outcomes, but policy, curricula, pedagogy, learning resources, perceptions, and practical exposure each play a determining role. These factors and others bear on whether a student grasps science and math concepts like hydrolysis or integrals and applies them in daily life. These factors comprise a *system* out of which secondary students emerge either ready to put math and science to work for themselves (and society) through continuation into higher education and/or employment.

Currently, the secondary math and science education systems of the EAC Partner States rarely align to assure student achievement of optimal learning outcomes. Missing or inadequate are those feedback loops between system components--curricular content, teacher training, learning resources, evaluation--that ensure an education system is continually optimized for relevance, quality, and access over time. One case illustrates this point. A "massive failure" occurred in Tanzania during the 2010 Form IV examinations in which over half of students examined failed, revealing a major breakdown in system alignment. Stakeholders pointed to a multitude of reasons for the catastrophic results – the inconsistent shift from content-based to competence-based learning, a lack of teaching and learning resources, the use of English as the language of instruction, poor teacher training, and/or the former multi-textbook policy. It is likely that each of these factors contributed to the larger system failure. However, vulnerability to such system breakdowns increases when these factors are appreciated strictly in isolation. When taking a holistic view, however, an array of inter-related challenges become visible that system-wide feedback loops can help mitigate.

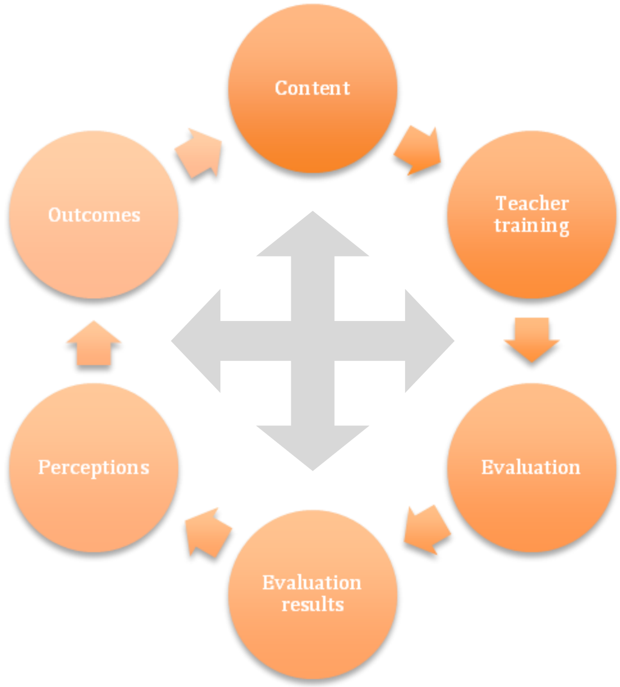


Figure B: Schematic of system dynamics that influence learning outcomes in math and science at secondary level

Considerations for regional cooperation and questions for further discussion

In advance of the regional strategic dialogue on harmonizing secondary math and science education, readers are invited to consider the following questions regarding Pillar Five as fodder for thought and discussion.

- What critical math and science skills and capacities need to be acquired through the course of secondary school? What processes best evaluate those learning outcomes?
- What role should the private sector and the scientific community have in determining priority math and science-based learning outcomes (e.g., helping to establish a regional qualifications framework)?
- How might various sectors – public, private, industrial, research, university, etc. – pertinent to the secondary math and science education system be better aligned for optimal performance? What feedback loops are needed?

"Of course, there is no way we can continue to be isolated. The world is a small village, and collaboration brings in good experiences. If good practices are pooled and shared, this can lead to overall improvement. It also builds the confidence of everybody, to know that what you are doing is good, that it is what other people are doing."

--Principal, National Teachers College Kaliro, Uganda

Conclusions and Considerations in Advance of the Regional Dialogue

In preparation for the EAC Ministerial Forum on Harmonization of Math and Science Secondary Education, one might wonder: how viable is harmonization? Is this an attainable goal in the near-term, or do we have decades of reform ahead before strides may be made?

While certain striking differences exist (e.g., number of years of secondary schooling, periodicity of examinations, divergent teaching career tracks), the research conducted during the elaboration of this Discussion Paper reveals close alignment between EAC Partner States in terms of secondary math and science education on a number of fronts. Practices of introducing competency-based instruction and enhancing teachers' grasp of pedagogical approaches to math and science instruction are underway in each of the Partner States. Efforts to boost the availability of teaching and learning resources offer another commonly observed initiative. Advances toward galvanizing industry and ensuring better alignment of supply with demand are accruing across the region. Such congruence bolsters the case for regional harmonization in secondary math and science education. In short, a number of near-term collaborative opportunities are within reach.

In many cases, the differences exposed constitute examples from which regional neighbors can learn from one another, rather than major barriers to harmonization. Rwanda's commitment to entrepreneurship training in secondary schools, for example, is not an impediment to regional harmonization. Rather, it is a novel input for regional learning, affording the other Partner States possibly a chance to replicate good practice.

In almost every one of our 120 interviews, respondents offered a range of reasons why regional harmonization of secondary math and science education should be pursued, including: opportunities for knowledge and resource sharing, exploitation of economies of scale in resource procurement, labor market mobility, quality enhancement through competition, and the development of minimum qualification benchmarks. One illustrative interview response follows:

> *I strongly feel [regional harmonization] is going to enhance secondary math and science education not only in terms of perceived performance, but also in terms of sharing experiences, inspiring other countries to achieve certain benchmarks, promoting a healthy competition between the countries, and many other benefits* (Coordinator of the National Assessment, Kenya National Examinations Council).

While feedback on the prospect of regional harmonization of secondary math and science education was generally positive, it was not free from concern. Interviewees consistently pointed to different languages of instruction, varying course and year requirements, and relative capacity disparities across the region as challenges that demand amelioration should regional harmonization of secondary math and science education move forward. Interviews gave rise to questions of quality standards in harmonization too. As one interview respondent stated, "Should we harmonize the poor quality we have everywhere? Or should we improve, and then harmonize?" (Representative, Excella Education Association, Rwanda) For all of these concerns, maintaining a focus on harmonizing *outputs* and *outcomes*, not necessarily *inputs* is critical. For example, so long as students in Kenya and Rwanda exit secondary school with the same competencies and qualifications should it matter that either the output or the subsequent outcome of that knowledge emerged over a different number of years?

These and other issues will be explored in greater depth during the proceedings of the regional dialogue. Until then, readers are invited to consider the remaining questions, as well as the others raised in the discussion paper, as fodder for the discourse that will occur in Arusha in late September 2011.

- What priorities for regional harmonization of secondary math and science education are shared across the EAC? What areas are important but not necessarily right for action now?
- What structural reforms and operating frameworks are still needed to help Partner States move toward more efficient and harmonized provision of quality secondary math and science education?
- What don't we know right now that we must know to move forward with regional harmonization of secondary math and science education?
- Who should the EAC Partner States engage in this process of harmonizing secondary math and science education? What mechanisms for stakeholder engagement should be institutionalized?

"Development of our country impacts our perceptions….By being a scientist, I can contribute. Parents tell us to do it. That's a big factor. I think there are good paying jobs in math and science. With science, you get to create your own employment trajectory."

--Student, Riviera Secondary School, Rwanda

Appendices

I. Interview Protocol

Introduction

(1) What is your full name and professional title?
(2) What are your chief responsibilities in your current role?
(3) By way of describing in more detail our research process, this endeavor focuses on five critical aspects of secondary math and science education: (1) Policy and governance, (2) Curricular content, (3) Teaching and learning resources, (4) Teacher training, professional development, and pedagogy, and (5) Evaluating learning outcomes. Of these 5 thematic areas, which most closely aligns with your core area of responsibility in your current position?

Pillar I: Policy and governance of secondary math and science education

(1) What are your country's priorities for secondary M&S (math and science) education? Are you aware of any policies that speak directly to M&S education at the secondary level?
(2) What quality assurance provisions are incorporated in the existing policy and governance structures for secondary M&S education? Are there mechanisms for secondary school accountability to national policy objectives and development goals?
(3) How are decisions impacting secondary M&S education made? To what extent and in what capacity do secondary schools govern themselves in terms of M&S education planning, implementation, resource allocation, curriculum design, and assessment?
(4) In your opinion, what is the reality on the ground in terms of governance and coordination of secondary M&S education? How effective are the policies that govern M&S education at the secondary level (in terms of access, quality, relevance and efficiency)?
(5) In your opinion, what is your country getting right in terms of secondary M&S education policy and governance? What are the opportunities for improvement?
(6) Do you see regional collaboration as a means to enhancing secondary M&S education for your country? If so, in what ways?

Pillar II: Secondary math and science curricular content

(1) How is M&S curriculum currently organized at the secondary level? Which subjects are required and which are elective? What are the intended curriculum characteristics (e.g., practical, theoretical, hands-on, experiential, memorization-based)?
(2) How is M&S curriculum planned? Who is involved? How effective are these processes in your opinion?
(3) To what extent are secondary M&S teachers engaged in the design & development of the curriculum they deliver? Do they have autonomy to modify the curriculum (e.g., change the sequence, add extra practical instruction, organize a field trip)?
(4) Are there efforts to review secondary M&S curriculum to ensure its relevance to national, economic, and social needs? If so, what is the status? When was the last review? How effective were these efforts?
(5) To what extent is the curriculum responsive to changing patterns of demand from students (allowing for differentiated learning pathways)? Employers? Institutions of higher learning?
(6) In secondary M&S curriculum, how are science concepts related to real-life application (such that, for example, incidence of malnutrition and disease exacerbated through lack of science literacy in the general population may be decreased)? How is theoretical knowledge of M&S balanced with practical application?
(7) In your opinion, what is your country getting right in terms of secondary M&S curriculum? What are the opportunities for improvement?
(8) Do you see regional collaboration as a means to enhancing secondary M&S education curriculum for your country? If so, in what ways?

Pillar III: Teaching and learning resources for secondary math and science education

(1) What is the availability of science and math textbooks? What is the average student to textbook ratios in subjects related to M&S?
(2) How well are schools/classrooms equipped with teaching and learning resources (e.g., labs, science-kits, demonstration resources, informal pamphlets) that help convey M&S concepts to students? What percentage of students have access to them? How often?
(3) How are M&S teaching and learning resources selected, procured, and distributed?
(4) What role, if any, do ICTs (information and communication technologies) play in the average secondary M&S classroom? How are ICTs integrated into the curriculum?
(5) Are you aware of any national plans to enhance the role of ICTs in secondary M&S instruction? If yes, what is the status?

(6) Are you aware of any efforts to engage the private sector, scientific community, and/or higher education institutions as resources for in-classroom instruction (such as through mentoring, work-exchange, or site visit programs)?
(7) In your opinion, what effect do teaching and learning resources have on student learning outcomes in M&S? How could they be made more effective?
(8) In your opinion, what is your country getting right in terms of teaching and learning resources for secondary M&S education? What are the opportunities for improvement?
(9) Do you see regional collaboration as a means to enhancing access to and utilization of teaching and learning resources for secondary M&S education? If so, in what ways?

Pillar IV: Secondary math and science teacher training, professional development and pedagogy

(1) How are secondary M&S teachers recruited? What basic competencies are expected of individuals who enter into secondary M&S teaching profession?
(2) How rigorous are the course requirements to become a secondary M&S teacher? How is content mastery evaluated? What opportunities for further professional development exist?
(3) Are teachers trained on how to utilize teaching and learning resources (e.g., ICTs, lab equipment) in the classroom? Are they exposed to these resources (e.g., ICTs, lab equipment) during their training? What impact does this type of teacher training have on their effectiveness and the overall impact on student learning outcomes?
(4) What efforts are undertaken to ensure alignment of supply and demand between secondary M&S teacher training structure and that of the secondary education system, both in terms of subject-matter competence and number of teachers needed?
(5) What incentives (or disincentives) drive individuals to teach secondary M&S education? How do these incentives impact M&S teacher quality and retention?
(6) What are the instructional practices for secondary M&S education (learner-centered, practice and drill)? How & with what impact is M&S education curriculum conveyed from teacher-training-institution to teacher to student? How are students involved in the process of improving their own learning? How is curiosity / problem-solving fostered?
(7) In your opinion, what is your country getting right in terms of secondary M&S teacher training? What are the opportunities for improvement?
(8) Do you see regional collaboration as a means to enhancing secondary M&S teacher training for your country? If so, in what ways?

Pillar V: Evaluation of secondary math and science learning outcomes

(1) How are secondary students evaluated in terms of their M&S knowledge? On what type of learning outcomes do the exams focus? With what frequency are they given?

(2) How is system-wide quality control achieved? Does it take the form of external examinations, teacher evaluations?
(3) Are there processes that ensure alignment between desired learning outcomes (as defined by national policies and local development, industrial, and economic needs) and evaluation practices? How effective are these processes?
(4) How do secondary students perceive M&S (e.g., do they aspire to professional careers in fields related to science, technology, and engineering or in other areas with a lesser emphasis on M&S)? What factors impact student perceptions of M&S?
(5) In your opinion, how responsive is secondary M&S education to local labor market skill needs and higher education requirements? Are those students exiting secondary schools adequately prepared for employment and/or continued education? How might this be improved?
(6) Are you aware of any mechanisms for tracking the destination of secondary M&S students into employment or higher education?
(7) In your opinion, what is your country getting right in terms of evaluating the learning outcomes of secondary M&S students? What are the opportunities for improvement?
(8) Do you see regional collaboration as a means to enhancing student readiness for the labor market and/or higher education? What implications might regional collaboration have for labor market mobility?

III. Perspectives from the Experts

The following is a composite interview with key quotes from interviewees in the five Partner States.

Pillar I: Policy and governance of secondary math and science education

What are your country's priorities for secondary M&S (math and science) education? Are you aware of any policies that speak directly to M&S education at the secondary level?

There is a 5-year development plan where all sectors fit in, and the policy of government is vocationalization of education, which science policy fits into as well. Students must come out of school with some employable skills, let them come out with something that can help them, and when they can continue as graduates it can still be helpful. Science comes in that way. – *Uganda: Secretary, Education Service Commission*

What quality assurance provisions are incorporated in the existing policy and governance structures for secondary M&S education? Are there mechanisms for secondary school accountability to national policy objectives and development goals?

The person in charge of a school is the principal, and he is in charge of ensuring all policies are implemented and guidelines followed. We [Ministry of Education] look at who is responsible, and most of the time the principal is asked to ensure that implementation is ensured. He should supervise his teachers. If they do not, they get demoted, or get transferred. – *Kenya: Deputy Provincial Quality Assurance and Standards Officer, Ministry of Education (personal opinion)*

How are decisions impacting secondary M&S education made? To what extent and in what capacity do secondary schools govern themselves in terms of M&S education planning, implementation, resource allocation, curriculum design, and assessment?

Secondary schools do not have any control – decisions are taken by the cabinet and bureau. But when there are so many meetings organized around a problem – in a subject. The parents and the teachers of different schools are invited to participate in such meetings. But do they decide? No. – *Burundi: Chef du Cabinet, Ministry of Primary and Secondary Education*

It's top down. The policy is developed at the national level. Then, it is brought down to the province level. And then to the districts. If schools perform poorly, it is not just the teacher's responsibility it's the entire community, in the context of school accountability for education provision. Private schools have an added pressure to perform well, because they are businesses and if they don't perform well, parents will not put their children in those schools. – *Kenya: Coordinator of National Assessment, Kenya National Examinations Council*

In your opinion, what is the reality on the ground in terms of governance and coordination of secondary M&S education? How effective are the policies that govern M&S education at the secondary level (in terms of access, quality, relevance and efficiency)?

We got an award from the United Nations for building the ward schools and having universal primary enrollment. But what about the quality? Classrooms – some are filled with 100 students and one teacher. They are all pushing each other. Form 5 and 6, it is the same thing. We do not have a curriculum, we just have the syllabus – if the teacher can even get it. Teachers do not even have the syllabus. You cannot even get it from the internet. – *Tanzania: Education Consultant*

Compared to other countries Rwanda is determined, focused on transforming policy into implementation. Even the president says that we don't have capacity, so we're going to borrow it. – *Rwanda: Capacity Development Consultants*

In your opinion, what is your country getting right in terms of secondary M&S education policy and governance? What are the opportunities for improvement? What are the challenges / bottlenecks your system faces in terms of secondary M&S policies and governance?

First, we realize our challenges. Identifying challenges itself is an issue. The provision of infrastructure and textbooks are increasing. Recently, the government hired teachers on contract, quite a large number – 4,200 in secondary schools. That was addressing the teacher shortage. Nevertheless, there is more to be done, because the primary children are now going on to secondary school. Enrollment of primary went from 5 million to 7 million after it became free [with universal primary education policy]. – *Kenya: Deputy Director, Post Primary Staffing, Teachers Service Commission*

Political will exists; the government is limited by resources, but there is a deliberate effort to equip schools with math and science teaching aids. Many rural schools teach theory. A student may take examinations without having seen an actual tool. There are attempts to build and equip laboratories. The government is putting quite a bit of budget on science education. – *Uganda: Deputy Director of Education, Kampala City Council Education Department*

Do you see regional collaboration as a means to enhancing secondary M&S education for your country? If so, in what ways?

I think that regional cooperation will be positive, but it depends on how they [member states/ governments] see it. We are not at the same level, but I think that becoming part of this community will be beneficial to the exchange of knowledge. The greatest problem is the language of teaching. The other member states use English, and it will take us some time to prepare ourselves for that. – *Burundi: Provincial Director of Education, Bujumbura*

Yes, it increases competition. The government will have to think about teachers' competencies and the quality of schools because now we will have compete in the region. – *Tanzania: Anonymous, Education Consultant*

Pillar II: Secondary math and science education curricular content

How is M&S curriculum currently organized at the secondary level? Which subjects are required and which are elective? What are the intended curriculum characteristics (e.g., practical, theoretical, hands-on, experiential, memorization-based)?

The Ugandan national education system is very theoretical-driven, with very little hands-on. Drawing from my own experience as student, we rarely got hands-on; most was detached from reality. There is a general outcry for the lack of hands-on. There is a component stressing theory, and a component stressing practical in laboratories, but that is really focused on passing exams. Little of that knowledge is applicable outside the laboratory. – *Uganda: Senior Lecturer, Department of Curriculum, Teaching, and Media, Makerere University*

The new curriculum is effective because, in fact, it takes in the perspective of teaching and learning processes. From what was in the beginning was stressing the content only, now the new curriculum emphasizes not only this, but also the competencies of the students and the learning and teaching processes. – *Tanzania: Principal Education Officer, Ministry of Education and Vocational Training*

How is M&S curriculum planned? Who is involved? How effective are these processes in your opinion?

The stakeholders are very broad. We look at the employers. We look at the market, what is the gap in the market in terms of skills, knowledge and competencies for graduates. We want to know what they think should be incorporated into education so they have employees who are competent. Also, we contact faith-based organizations, political organizations, the business community, teachers, students, parents, development partners and NGOs. We want a broad understanding of what is demanded from the curriculum. – *Tanzania: Director, Research, Information and Publication, Tanzania Institute of Education*

The Minister of Education decides … When they go in the field, they gather samples and they analyze those samples. If there is a chapter that needs changing, they put together the ideas and they put it to the minister and he decides whether the program changes or is maintained as it is. – *Burundi: Math Adviser, Bureau d'Etudes des Programmes de l'enseignement Secondaire (BEPES)*

To what extent are secondary M&S teachers engaged in the design & development of the curriculum they deliver? Do they have autonomy to modify the curriculum (e.g., change the sequence, add extra practical instruction, organize a field trip)?

We here during the training make [teachers] think outside the box. You are the one to interpret the syllabus, so you teach accordingly as long as you are within the defined content. You can modify, start there looking at your learners, as long as you are going to cover what is there. – *Tanzania: Education Officer, Ministry of Education and Vocational Training*

We bring teachers in, but the only problem is they may not go very far upcountry to find teachers, they limit it to a close range within Kampala. [Autonomy] depends on the school, some do and some don't. Most schools don't; it depends on finances. – *Uganda: Assistant Secretary, Uganda National Examinations Board*

Are there efforts to review secondary M&S curriculum to ensure its relevance to national, economic, and social needs? If so, what is the status? When was the last review? How effective were these efforts?

[The last review] was in 2008. It is effective. You see, the review for curriculum development is a process. You don't go and then stop. You keep on reviewing because the knowledge is not static, it is dynamic. When there is a need, you review the curriculum to respond to the needs of society. And I believe that the curriculum developers respond to it. – *Rwanda: Entrepreneurship Expert, UNIDO*

There have been two great events in the education sector. The first was in 1989. That is when the curriculum was reformed. Many important things have been done, including in science. So the problem is that it was not financed, so it was not implemented. So the government has not allocated the consequent budget to implement. The second moment was 2008-2009 when UNESCO asked them to revise the program. And now, math and science have a revised program, and it is there. So it is also multiplied so they have many copies of that, so it is up to the ministry to take them and use them, but they are available. And UNESCO is ready to train the teachers so that they can be able to use those new programs. I am saying "new" program, but really they are revised. This is an opportunity that must be seized by the ministry. – *Burundi: Education Program Officer, UNESCO*

To what extent is the curriculum responsive to changing patterns of demand from students (allowing for differentiated learning pathways)? Employers? Institutions of higher learning?

In my ideal situation, we should involve the consumers, involve the industry a little more, because they should tell us what kind of students they want at the end of the day. We are dealing with students whose lives are full of ICTs, not just a computer. We are dealing with a very versatile group, and if we are teaching students the same today as yesterday, that is wrong, they have their own style. If students are told to go to the library and research a vocabulary word, they won't do that, they'll Google on their phones. – *Kenya: Head of Computer Studies Department, Kenya Technical Teachers College*

There is a gap between universities and secondary schools. We may have a subject at secondary, then the university may call a core subject "minor" and students may not focus on it enough. Universities don't care about what is being taught in schools. Teachers don't have a chance to look at the curriculum and syllabus of universities. Students don't have chance to see college curriculum. – *Uganda: Secondary Mathematics Director, National Curriculum Development Center*

In secondary M&S curriculum, how are science concepts related to real-life application (such that, for example, incidence of malnutrition and disease exacerbated through lack of science literacy in the general population may be decreased)? How is theoretical knowledge of M&S balanced with practical application?

At Riviera, we encourage students to do research. They have projects they take up and come present. It's about applying what they learn in class to environment they face. All teachers take up the issue of research. Teachers too must elaborate more. So, if you teach a given topic, you must relate it to the issues people face in their real lives. Again, we have our students doing practicals too. This way, they are doing more than theory, but experimentation. – *Rwanda: Dean of Students, Riviera Secondary School*

One of the main challenges within sciences and mathematics, even from my own experience, is that it is too much theoretical. Science is supposed to be almost 50/50, but here we focus a lot on the theoretical aspects. There should be an almost equal effort on the practical aspect. Other factors hinder the practical aspect, especially equipment. When you look at the performance of sciences in secondary school, you find that most schools do not have laboratories. So you see there is a total disconnect. You only see microscopes in a book. That contributes to more than 50% failure rate in the sciences. You have the theoretical, but not the practical. – *Kenya: Programs Officer, Kenya Private Sector Alliance*

In your opinion, what is your country getting right in terms of secondary M&S curriculum? What are the opportunities for improvement? What are the challenges / bottlenecks your system faces in terms of secondary M&S curricular content?

At the moment, we've introduced the Cambridge System into Rwanda. It's a system that looks more at the applicability of what you've studied. It was a big deal to bring it in. By contrast, if you look at Uganda, it's read and then pass. There's little applying what you've read. People finish studies and can't create something of their own. We want students to apply what they learn to the real world. When they do it, they will come to appreciate science even more. – *Rwanda: Dean of Students, Riviera Secondary School*

When we are devising curriculum, we are strong in that area because we cover three domains. The first is cognitive: That is reasoning. The second is affective: That is values. The third is psychomotor. That is skills development. The psychomotor is very important. The content in our curriculum will address the cognitive structure of the student, their reasoning. The cognitive is emphasized the most. We should balance the three, but mainly reasoning when we deal with science. – *Tanzania: Principal Education Officer, Ministry of Community Development, Gender, and Children*

Do you see regional collaboration as a means to enhancing secondary M&S education curriculum for your country? If so, in what ways?

There should be three types of content: regional content, national content, and more local content. If you are going to work in Tanzania, I need to know what they know in math and science, and what Kenyans know in those areas. Science and maths are interesting because they are international, not specific to any country. Whether you do it in America or New Zealand, it is the same. So in East Africa we need to agree on the content we need to teach in science and mathematics, so if I go to Tanzania I don't feel incompetent or inferior. – *Kenya: Education Consultant, Japan International Cooperation Agency*

Mobility of labor in the region and worldwide requires curriculum to be on par with rest of world. This is one good argument for curriculum harmonization. Free labor mobility can only happen in the EAC if there is the same curricular content. Degrees need to be equivalent in terms of content, and on par with what is happening globally. For teachers to teach curriculum to be able to move, they need to be able to impart these skills and know what is expected of them when they move across borders. It would be much easier if curriculum was the same. Teachers could teach in Uganda, Kenya, Tanzania – they could easily move and teach in these places. –

Uganda: Assistant Executive Secretary, Uganda National Council for Science and Technology

Pillar III: Teaching and learning resources for secondary math and science education

What is the availability of science and math textbooks? What is the average student to textbook ratios in subjects related to M&S?

Rwanda has shifted from French to English in the past two years. In many secondary schools, we don't have books in English. Some teachers have tried to translate the French books themselves, but their English is not very good. Teachers haven't been prepared to instruct in English, even though they have been obliged to teach in English for two years. – *Rwanda: Head of Physics Department, Faculty of Science, National University of Rwanda*

It varies from context to context. In public and private schools in urban areas, you hardly find that complaint, but even in Kampala there are schools that have almost no resources. It is a big issue. There are many schools around Kampala itself, and outside Kampala, where we can't recommend teachers to go because they wouldn't get good training because of lack of resources. Even schools that have resources, some books end up being locked up in the head teacher's office. They want to keep them clean, they think students might spoil them. When they are lucky, the teacher might be able to use them for lessons, but they go back to the office after the lesson. – *Uganda: Senior Lecturer, Department of Curriculum, Teaching, and Media, School of Education, Makerere University*

How well are schools/classrooms equipped with teaching and learning resources (e.g., labs, science-kits, demonstration resources, informal pamphlets) that help convey M&S concepts to students? What percentage of students have access to them? How often?

A physics lab is there, there is a chemistry one, and biology. But the equipment they need is not: there is no equipment for the laboratories. No chemical products, no physics products. Sometimes we can undertake to make an experiment. With no material you can't do it. You just explain how to do the experiments. To study physics like you study history is very scandalous, very scandalous indeed. – *Burundi: Secondary Physics Teacher, Lycée du Saint Esprit*

Resources are scarce in Uganda – teachers, textbooks, labs, lab equipment, and ICTs are all lacking. This is due largely in large part to the universal education policies, which have increased enrollment without an increase in resources of the same scope. The government is trying to address these gaps – for example, by acquiring computers and setting up school networks – but the challenges still remain. – *Uganda: President, Uganda National Academy of Sciences*

How are M&S teaching and learning resources selected, procured, and distributed?

In public schools they have the Public Procurement Act – which announces a tender and you have a tender committee to choose the best bidder then you procure someone to provide to schools. But they are books and materials that have been approved by EMAC. That is the public way but it is very expensive – you find a book that is three times the price because it is the "delivery" price, not the shop price. You have a book that is $5 in the shop but you want them to deliver it to you it costs $15. That is the system, it is very expensive. Me, as director of my school, I go to the shop, I negotiate, if I am buying a lot I say you must give me a discount and there is no middleman. It is cost-effective. – *Tanzania: General, Tanzania Association of Managers and Owners of Non-Governmental Schools and Colleges*

There are some textbooks that are elaborated by the BEPES. So the textbooks elaborated by BEPES, the manuscripts are sent to - the drafts are sent to the printer. We call the printer EPP. There they just print, and the bureau sends to the schools. For the older materials that are not elaborated by BEPES, they are just purchased from outside [other countries]. – *Burundi: Advisor to the Cabinet, Ministry of Education*

What role, if any, do ICTs (information and communication technologies) play in the average secondary M&S classroom? How are ICTs integrated into the curriculum?

The way I understand it is it is not a 100% integration. It is going to be phased in terms of one session or two sessions in a particular subject. It will take time. In any case, the content for pedagogical learning is still being developed. So far they have only done Form 1 and Form 2, so we are still in the process. Using ICT approaches in teaching cannot be a complete phase-in. – *Kenya: Manager, Education Management Information System, Ministry of Education*

At least 10 computers and internet connection were given to all schools in Rwanda, but no money was provided to maintain the equipment and connection, so most have gone out of use. The government has supported all schools, giving them 10 computers per school and wireless connection. The problem is how to maintain the equipment and connection, as it is expensive. Most are now out of use. – *Rwanda: Head of Physics Department, Faculty of Science, National University of Rwanda*

Are you aware of any national plans to enhance the role of ICTs in secondary M&S instruction? If yes, what is the status?

There is a flagship project under the economic stimulus with about one million shillings spent, in schools across the country. At least five schools in each district (285 districts) will have a model computer lab. They ask them to have a classroom, then equip the labs with computers. – *Kenya: Manager, Education Management Information System, Ministry of Education*

We have had a number of efforts. One is SchoolNet, one is Cyber School. I tried both of them, but I think the approach needs a lot of revision. When I was headmaster of another school, I kind of evaluated at a local level, the school level. I evaluated the benefit of Cyber School, and I found it extremely expensive for hardly any result. Fees were too high, and at the end of the day I didn't see students or teachers benefit much. The models we've been using have not been the best in my view. At that school, I asked the government to pay, and they did, but even getting what they pay for is very difficult. Sometimes they will bring a CPU without a screen for example. – *Uganda: Headmaster, King's College Budo*

Are you aware of any efforts to engage the private sector, scientific community, and/or higher education institutions as resources for in-classroom instruction (such as through mentoring, work-exchange, or site visit programs)? Are other communities seen / used as resources for secondary M&S students and teachers? If so, what examples are there of these practices? If not, why?

In secondary school, students are normally taken to higher learning institutions to open their minds and see where they trying to reach. Here we will see groups a few times a year. Industrial visits, and industrial attachment (internship) at the end of 5th year of technical school regarding science. Except that they visit labs of higher education, the private sector is not interested in that because it does not generate money immediately. It is a long-term investment and in our country it is not there. – *Rwanda: Director of Academic Services, Kicukiro Technical Training Center*

Yes, to some extent, there are parallel activities to in-class learning. Due to the existence of clubs such as Club UNESCO, Club HIV-AIDS, Club Theatre, it is possible to visit some institutions of reference. At the technical secondary education there are unpaid internships that are part of the students' final evaluation, and the same thing in higher education. Local companies ask universities and technical schools to send their students, preferably the best and brightest, and those who have an outstanding performance will be recruited or kept under a close watch until their finish their studies. However, there are not enough companies to absorb the increasingly larger number of students seeking host institutions. – *Burundi: President, Parent's Committee, Lycée du Saint Esprit*

In your opinion, what effect do teaching and learning resources have on student learning outcomes in M&S? How could they be made more effective? What difference does having access to teaching and learning resources have on the student experience, on retention of theories and facts? Can you give any examples of this impact, good or bad?

Having materials is one thing … actually utilizing them is another thing. If the learning resources could be there, that's great, but it is a matter of the teachers helping the students. If they could do this, the outcome would not just be good, it would be very great. – *Tanzania: Lawrence Mass Communicator, Tanzania Higher Learning Institute Student Organization*

When you hear and see, you retain, but when you hear, see, and do, you retain almost everything. When a teacher lectures and gives homework, that will help the student understand, but when you have hands-on activities – the charts, the lab equipment, the chemicals, if you literally do the experiment yourself, put this chemical in, this chemical – you actually retain it more. I think the focus should be that you have adequate teaching and learning resources. – *Kenya: Deputy Provincial Quality Assurance and Standards Officer, Ministry of Education (personal opinion)*

In your opinion, what is your country getting right in terms of teaching and learning resources for secondary M&S education? What are the opportunities for improvement? What are the challenges / bottlenecks your system faces in terms of secondary M&S teaching and learning resources?

The government has done a very good initiative to demystify maths, which is a problem in teaching. They have come up with videos. When they work with fractions for example, they bring out a cake, cut it into two, cut it into four. That is really improving demystification of maths. - *Kenya: Head of Computer Studies Department, Kenya Technical Teachers College*

The effort to use ICT is right, that is the direction we should be moving. Every school talks about incorporating ICT into training programs, and I think they have completed ICT curriculum which will be embedded into schools. It will be interesting to see how they follow it up, but we now have the problem of trying to get on board. People in the field are unfamiliar with new technology, and that is where professional development comes into it. How do we bring them on board? The idea of continuous professional development comes into play. We need a new scheme, a project for that. It should also be institutionalized. – *Uganda: Associate Professor, Department of Science, Technical, and Vocational Education, School of Education, Makerere University*

Do you see regional collaboration as a means to enhancing access to and utilization of teaching and learning resources for secondary M&S education? If so, in what ways?

There is something I was looking at in the Commonwealth [of Nations] of learning trying to do an initiative on flexible skills development, so we could collaborate, get access to source code, adapt to our situation. I think it can be done. The problem we have is that there are so many initiatives; initiative A is doing good things, initiative B is doing good things, they are neighbors but they don't know about each other. There is duplication. Collaboration, networking, and bringing all this together would be able to us help stop reinventing the wheel. Because, after all, the content can be good, but one small difference can make it bad. – *Kenya: Head of Computer Studies Department, Kenya Technical Teachers College*

I think it would help in terms of resource sharing and seeing examples of good practice, and igniting some kind of envy so we can improve things here. With the issue of using computers in classrooms, Rwanda is way ahead, they have embraced using ICTs. There is a commitment on the part of the Rwandan government to provide computers to classrooms, and collaboration could help spread that to Uganda. - *Uganda: Senior Lecturer, Department of Curriculum, Teaching, and Media, Makerere University*

Pillar IV: Teacher training, professional development, and pedagogy for secondary math and science education

How are secondary M&S teachers recruited? What basic competencies are expected of individuals who enter into secondary M&S teaching profession?

It is the school who presents the needs. And it is up to the District Direction Provincial of teaching (Department Provincial Ensignment). This guy (DPE) sends the whole application to the Ministry of Public Services. That is for newly recruited teachers. They don't choose teachers based on their schools grades or university grade. They just look at the diploma. – *Burundi: Director of Natural Sciences, Ecole Normal Superior*

There is a level after high school where you have the option and you select the subjects in which you were best. People find themselves teaching science because they were best compared to other studies. They put more effort in those subjects. In other countries they choose from the beginning which field they want. Here you choose a bit later, after high school. – *Tanzania: Teacher, Paradigms Secondary School*

How rigorous are the course requirements to become a secondary M&S teacher? How is content mastery evaluated? What opportunities for further professional development exist? Is the secondary M&S teacher training curriculum considered difficult? Easy? Does it adequately prepare teachers to instruct on M&S subjects?

After having trainings, we improved / changed the way we work. We have to give more voice to the student than to the teacher. Students are invited to participate more than the teacher. There is a difference in what they have learned. Now the learner has to participate and discover more than we just the information we give them….Students are interested in learning science and many times they prefer to learn sciences more than other courses. – *Rwanda: Math and Science Teachers, Elena Guerra Secondary School*

Who enters teacher training colleges? Just students, but to be a teacher they have to learn pedagogy, science subjects, and after they are qualified as teachers. Once they go to schools they are still not real teachers – they are just on the starting line. There are so many things they can learn in the field, and from that point of view – consistency is needed from pre- to in-service, but there must be some particular area they can learn from INSET, which is more practical. It has to be ongoing; teaching is a profession where you have to brush up every day – an endless training process. – *Uganda: Technical Advisor, SESEMAT*

Are teachers trained on how to utilize teaching and learning resources (e.g., ICTs, lab equipment) in the classroom? Are they exposed to these resources (e.g., ICTs, lab equipment) during their training? What impact does this type of teacher training have on their effectiveness and the overall impact on student learning outcomes?

Those who are teaching now are not trained on that. Those who graduate in chemistry, physics, biology on laboratories, yes. For ICTs I don't know if I can say. They learn to use it – I don't think so. I think they learn to use ICTs for their studies here, not for their teaching. – *Burundi: Vice Dean, Faculty of Science, University of Burundi*

Teachers in SMASSE are given emphasis on using available resources for use in class. If the ministry is not providing, then the school headmaster provides. Our emphasis on improvisation means you might not if you have the conventional operators. During training at universities and colleges, there is very little emphasis on pedagogy. We focus on methodology and subject content, so if a school has equipment – many which do have equipment do very well – having been trained, they are likely to know how to use that. However other schools that do not want to perform experiments, that just want to talk and show, that is what we focus on changing with ASEI. – *Kenya: Education Consultant, Japan International Cooperation Agency*

What efforts are undertaken to ensure alignment of supply and demand between secondary M&S teacher training structure and that of the secondary education system, both in terms of subject-matter competence and number of teachers needed?

There is a low supply and you know that if there is a low supply, there is high demand. The big problem comes, since there are few and in high demand, they are concentrated in urban areas where they can get employment and other social services. You go to remote areas, and you won't find them. Now what the government is doing now, for those who want to join the teaching professions, the first priority is given to math and science. The first criterion for applying is math and science. – *Tanzania: Teacher Education Department, Ministry of Education and Vocational Development*

There are two aspects. First, numbers: there is a structural difficulty in the country, in that there is a perpetual shortage of math and science teachers (and English language), and it is kind of historical. It carries on and I don't know when we shall break it. The number of students aspiring to do science and mathematics is not so big, and we have to share them with other tertiary institutions with math and sciences. There has been significant improvement over the last three years, the numbers are coming up, so we think in the long run we will get enough numbers. Second, we cannot get much more because the training facilities limit it. For example, we can take 40 in a lab, and if we take more than 40, that will constrain the teaching. – *Uganda: Principal, NTC Kaliro*

What incentives (or disincentives) drive individuals to teach secondary M&S education? How do these incentives impact M&S teacher quality and retention?

The disincentive is the low salary. If you don't get salary, it's everything. Retention is a big problem…if people have offers for more money, they just leave. There is another factor: even if the job of teacher is less well paying, there may be few options that present alternatives. – *Rwanda: Math and Science Lecturers, Faculty of Sciences, Kigali Institute of Education*

You need a community that believes in you. Teachers need to be respected individuals in a community, and then you will have motivation. That discourages some from giving services in certain areas…Many teachers are stacking in the center, more in urban areas, including certain regions where people say I do not want to work there, I would rather resign. – *Uganda: Associate Professor, Department of Science, Technical, and Vocational Education, School of Education, Makerere University*

What are the instructional practices for secondary M&S education (learner-centered, practice and drill)? How & with what impact is M&S education curriculum conveyed from teacher-training-institution to teacher to student? How are students involved in the process of improving their own learning? How is curiosity / problem-solving fostered?

Here in Rwanda we have a policy on "learner-centered pedagogy." How it's being applied is another thing. However, it is expected that all institutions follow this. It means we are not the provider of knowledge, we facilitate the students constructing the knowledge. But there are challenges, because of facilities, you cannot tell people to do things if they have no access to reagents, etc. Because of lack of resources, the implementation is very hard. In each module, it will depend upon the capability of the lecturer and degree of availability of resources. – *Rwanda: Math and Science Lecturers, Faculty of Sciences, Kigali Institute of Education*

One, the policy is learner-centered teaching. There is one challenge – the teachers trained in content-based are teaching in learner-center approach with no retraining. They have not been reoriented in the new approach…That is one of the big factors of the mass failure – the mixture of these 2 approaches. The students start in the content-based and then in the middle of their learning they start in the learner-centered approach using a mixture of teachers from content-based and learner-centered. – *Tanzania: Secretary General, Tanzania Association of Managers and Owners of Non-Governmental Schools and Colleges*

In your opinion, what is your country getting right in terms of secondary M&S teacher training? What are the opportunities for improvement? What are the

challenges / bottlenecks your system faces in terms of secondary M&S teacher training?

We organized teacher training with the help of Belgium. And we only had the opportunity to do it during the holiday. We had only 40 teachers, only for three years…So if I count I can say that we trained around 120 teachers – it is not enough. It is very small compared to what we should do. We should find money from somewhere for every year. A structure that can last. – *Burundi: Thaddee Barancira, Vice Dean, Faculty of Science, University of Burundi*

We have taken many initiatives recently that I think are very good. First, we have started abolishing alternatives to practicals. We are providing the opportunity to do practicals and I think that is a big score. Second, we are improving teacher quality and training because of the new in-service trainings (through JICA). Third, we are conducting pre-entry training for A-level leavers going into teacher training colleges in physics, math or English. It started this year and we have 1200 prospective teachers over the last 5 years. – *Tanzania: Assistant Director, Teacher Education Department, Ministry of Education and Vocational Development*

Do you see regional collaboration as a means to enhancing secondary M&S teacher training for your country? If so, in what ways?

Education reform cannot be done from the top down, but from the bottom up, simply because quality assurance of learning takes a long time to monitor and evaluate. We have twelve trainers, who cannot visit all the schools, that is not possible, and is not the model we want to establish. However, one teacher from a school can see another teacher at another school. Peer-review can strengthen the learner-centered approach, and teachers can learn from each other. – *Uganda: Technical Advisor, SESEMAT*

We've already benefiting from collaboration … An example would be during the English language change. The Ministry of Education collaborated with the Ministry of Education in Uganda to have teachers come to support English training. Trainers training teachers. There is a lot more we can gain from regional collaboration in terms of training, exchange, student visits, textbooks, learning materials. – *Rwanda: Director of Rwanda Office, FAWE*

Pillar V: Evaluating secondary math and science learning outcomes

How are secondary students evaluated in terms of their M&S knowledge? On what type of learning outcomes do the exams focus? With what frequency are they given?

In maths it is not a student who remembers formulas that is a good mathematician. It is someone who can apply those formulas. So questions, issues, even those we are not taught … so the application is the best outcome. Now the questions demand more piloting. Every three, four years the questions are the same again. If you have a good memory, you can pass. Being a mathematician is not just having a good memory. It is application. The exams should test that. They should test application or the level of association – those would be outcome-based exams. You look at exam papers now and you do not see that. – *Tanzania: Program Officer for Capacity Development and Innovation, Tanzania Education Network*

We want teachers to think of the other side of science…not just theory, but the practical side. So, during the setting of the paper [the exam], we are asking them to think of one question that is practically oriented. At least this way, there is some sense of reality to the real world. Shortages of practical apparatus, etc., pose constraints. The goal was a practical paper for O level, to match this change at A level. Our near-term goal is to create a practical exam. – *Rwanda: Representatives from Rwanda National Examinations Council*

How is system-wide quality control achieved? Does it take the form of external examinations, teacher evaluations?

We are starting to develop that type of quality control right now … With these evaluations, the government tries to assess what instructional competences teachers demonstrate. Are they up to the task? What do they think that needs to be improved? What is the level of parents' engagement? The system of teacher evaluation is not implemented yet, it is being discussed. – *Kenya: Coordinator of National Assessment, Kenya National Examinations Council*

Yes, because in our system we have an office in charge of assurance. And what is difficult today is that problem of no in-service training. Just some officers go in schools to see how teachers teach, how they do their activities, and discuss about some problems or some challenges. But the problem is the feedback of what they have seen. The challenge they have seen in the classroom because we have no policy on in-service training. That is the big challenge of our system. – *Burundi: Anonymous, Ministry of Primary and Secondary Education*

Are there processes that ensure alignment between desired learning outcomes (as defined by national policies and local development, industrial, and economic needs) and evaluation practices? How effective are these processes?

MOEVT with TIE ensures that we develop a culture of scientific knowledge from primary schools. This is where you can get a big number of students attending the science subjects because the primary levels do not have the distinctions between the science or arts streams. The alignment done by the Ministry is to ensure that in order to get students to work in scientific institutions, you need to build the skills while the students are young. You need to look at what the universities and higher institutions need in terms of scientists and then you align that need with the education system. That way they grow with the requirements. This has been done. However, the implementation has been problematic because most of the time the students that are doing well in the science subjects are not being recognized and rewarded. – *Tanzania: Director of Information and Documentation, Commission of Science and Technology*

Sadly, there is no alignment. There is a lack of will but especially it lacks an organization from the Government, a vision to implement this alignment. It is important to understand the country's needs in order to have local, industrial and economic development. Something is missing here. There is a need to develop political programs that will help the Government to diagnose the challenges and current problems, which would be followed by an action plan and monitoring programs. – *Burundi: President, Industrial Association of Burundi*

How do secondary students perceive M&S (e.g., do they aspire to professional careers in fields related to science, technology, and engineering or in other areas with a lesser emphasis on M&S)? What factors impact student perceptions of M&S?

In general, students are afraid of math and to pursue advanced studies in that field because the only job opportunity they can aspire to is a teaching career and teachers are not well paid. In the field of sciences, students aspire to a career in medicine and engineering. – *Burundi: President, Parent's Committee, Lycée du Saint Esprit*

Students can choose what to do, but there is a perception that only the good students in schools should do math and science. The poorer ones are discouraged from taking the sciences. Most students want to do things like medicine, architecture, engineering. If you talk to students in Kenya, they know these are the lucrative professions. But what happens is that very few take the sciences. – *Kenya: Deputy Provincial Quality Assurance and Standards Officer, Ministry of Education (personal opinion)*

In your opinion, how responsive is secondary M&S education to local labor market skill needs and higher education requirements? Are those students exiting secondary schools adequately prepared for employment and/or continued education? How might this be improved?

I doubt that students leaving secondary school are prepared for specific employment. Even those leaving university find almost nothing on the job market. The others are even less employable, though they may accept work of any kind willingly. We have so little industrial development, the market isn't absorbing them. That is just not the case in Rwanda. Everyone wants to be employed by the state. – *Rwanda: Representatives from Rwanda National Examinations Council*

I think they are quite well prepared for continuing education, but preparation for the labor market is still a problem. The preparation tends to be very theoretical, very little hands-on. Take, for example, students of agriculture. This is an agricultural country, but the way students are prepared in agricultural classes, there is no practical agriculture. Even in practical papers, there is nothing practical. I would expect that practical agriculture would involve maybe students having small plots where they can cultivate something, or look after small animals such as poultry, but that has not happened. All they do is identify tractor parts, tools they use, things like that. Preparation for the labor market is still lacking. – *Uganda: Principal Examinations Officer, National Assessment of Progress in Education, Uganda National Examinations Board*

Are you aware of any mechanisms for tracking the destination of secondary M&S students into employment or higher education? If so, what are they? If there is no hard evidence, what anecdotal information is available to reveal where secondary M&S students end up?

Yes. They have established a way of tracking the learners and following up and even after some years, get feedback. These students who studied this, where are they and what are they doing? It may not be reinforced, but it is there. There is something called the Labor Market Information Systems - this is an institution that follows up the linkage between the labor market and technical school. So, what information does the market need, how many jobs were created, what does the labor market need and how can we get this labor? Then they have a follow-up. There are mechanisms, but they are not reinforced. – *Rwanda: Entrepreneurship Expert, UNIDO*

Before the crisis, there were statistics on "this many people went in science, this many went to chemistry," before the crisis, before 20 years ago … The students made a choice and the government saw how many sectors before they are in [went into] the program. And they saw what kind of qualification was needed. I think now this is not happening. – *Burundi: Director General, Info Com Burundi*

In your opinion, what is your country getting right in terms of evaluating the learning outcomes of secondary M&S students? What are the opportunities for improvement? What are the challenges / bottlenecks your system faces in terms evaluating secondary M&S learning outcomes?

The evaluation is based on curriculum. I see evaluation as being fully aligned with curriculum. The weaknesses that come are due to the nature of the curriculum, which emphasizes theory as opposed to practical work. Of course I would want to see a component of continuous assessment, because science is really practical work, you need to have done projects. – *Uganda: Principal Examinations Officer, National Assessment of Progress in Education, Uganda National Examinations Board*

They are doing well in evaluating the syllabus. In my opinion, the alternative – the one we refer to as lower mathematics – should be reviewed, because I feel that there are still more intense topics that should be reviewed. It is a bit high-pitched for people not taking science-oriented courses. Alternative A is good for the country and for future technological development, even for the sciences. – *Kenya: Examinations Secretary, Mathematics, Kenya National Examinations Council*

Do you see regional collaboration as a means to enhancing student readiness for the labor market and/or higher education? What implications might regional collaboration have for labor market mobility?

Yes, the only challenge that might be there is that we have different educational systems. The first thing we must do is have a national qualification framework. Some subjects, like maths and sciences, are career subjects that can be taken anywhere. Mathematics is mathematics, no matter where you are. Skills undertaken in other countries are known. If you have a framework, you could say someone with grade A in Kenya can fit in at this level in another country. If this happens, it could create an impetus in countries and more emphasis on science and mathematics, more hope that if you take science and math, you can collaborate very easily with those and move around. – *Kenya: Council Secretary/Chief Executive, Kenya National Examinations Council*

If we don't put quality evaluation in our system, we don't succeed in harmonization. We can say we have the same curriculum, but used differently it will not help countries who have done efforts. – *Burundi: Evaluation Specialist, PARSEB*

III. Roster of Interviewees

Burundi Math and Science Secondary Education Interviewees

Institution	Interviewee's Name	Interviewee's Title	Picture
Burundi Ministry of Primary and Secondary Education	Liboire Bigirimana	Chef du Party	
	Jean-Marie Rurankiriza	Advisor to Minister of Primary and Secondary Education/Cabinet	
	Oscar Bazikamwe	Director of Education Planning	
	Corinthe Nzohabonayo (left)	Director of Inspection	
	Simon Niyibigira (center)	Education Inspector	
	Ernest Hakizimana (right)	Education Inspector	
	Mukene Pascal	Political Advisor, Bureau of National Evaluations	
	Félix Mpozeriniga	Advisor to Minister of Primary and Secondary Education/Cabinet	

	Donatien Muryango	Regional Inspector of Secondary Education (Office of Inspector General)	
	Antime Mivuba	Advisor to Minister of Primary and Secondary Education/Cabinet	
Provincial Direction of Education Mairie (Bujumbura)	Rénovat Nzeyimana	Director	
Burundi Ministry of Higher Education and Scientific Research	Benjamin Sezibera	Director of Scientific Research	
	Jovith Ngendakuriyo	Director of Science, Technology and Innovation Promotion	
Ministry of East Africa Community Affairs	Thaddée Ntahondi	Communication Advisor	
University of Burundi	Joseph Bigirimana	Professor of Agronomics	
	Alexis Banuza (right)	Teacher training expert	
	Thaddee Barancira (left)	Vice Dean of the Faculty of Science	
	Mathias Bashahu	Lecturer, Institute of Applied Pedagogy, Department of Physics and Technology	
	Alfred Ndiaye	Lecturer of Physics and Mathematics, Department of Physics and Technology	
	Léonard Nduwayo	Professor of Physics	
Burundi Ministry of Primary and			

Secondary Education			
Lycee de Vugizo	Alphonse Ndayriziye	Headmaster	
PARSEB (Project D'Aapui a la Reconstruction du System Educatif Burundi)	Hercule Yamuremye	Evaluation Specialist	
Ecole Normale Superieur	Prosper Ndizeye	Head of Department of Natural Sciences	
	Janviere Ndirahisha	General Director	
Kamenge Technical College	Terrance Manirakaza	Director of Technical Education	
Bureau of Studies and Secondary Education Curriculum Development (BEPES)	Sylvere Cambara	Chief of BEPES Math Team	
	Tharlisse Nitonde	Math Advisor	
	Juvenal Ndirahisha	Math Advisor	

	Gloriose Baradamarkanya	Math Advisor	
	Emmanuel Niyonsaba	Math Advisor	
	Phocus Ntakerutimana	Math Advisor	
	Joel Gashoka	Director	
BEPEP (former Bureau of Rural Education)	Mathias Niyonzima (top, right)	Pedagogic Counselor	
	Elie Barutwanayo (left)	Pedagogic Counselor	
	Marcelline Ntakaburimuyo (top, left)	Pedagogic Counselor	
Information and Communication Technologies Sector-based Chamber (Chamber of Commerce)/INFO Com Burundi	Deo Bizimana	President/Directeur General	
Institute of Statistics and Economic Studies of Burundi	Vénérand Nizigiyimana	Director of Economic Studies	

(ISTEEBU)			
ECONET Wireless	Francine Ihorihoze	HR Manager	
Industrial Association of Burundi	Econie Bijimbere	President of the IAB and CEO of Mister Minute Service (Printing Company)	
Lycee du Saint Esprit	Jean Claude Nduwayezu	Physics instructor	
	Eduard Barunsanzaha	Physics instructor	
	Roger Gateretse	President of the Parents' Commission	
Lycee Municipal Rohero	Gertrude Simbananiye	School Director	
Lycee Buhonga	Cynthia and Jane	Secondary Students	
Mayemba Communal College	Tharcisse Gatambutsi	Headmaster	
Bureau of Evaluation	Patrice Manengeri	Director	
UNESCO	Paul Ngarambe	Program Officer in Education	

Kenya Math and Science Secondary Education

Interviewees			
Institution	Interviewee's Name	Interviewee's Title	Picture
JICA (Japan International Cooperation Agency)	Samuel Kibe`	Education Consultant	
Kayole Secondary School	Martha Kimarou	Head of Science Department	
	Anne Simba	Dean of Studies	
	Caroline Ationo	Form 4 student	
Ministry of Education	Florence Hungi	Senior Quality and Standards Assurance Officer	
	Charles Obiero	Senior Economist	
Kenya National Council for Science and Technology	Said Hussein	Chief Science Secretary	
	Moses Rugutt	Deputy Council Secretary	
Kenya National Examinations Council	Rose Ndaana	Examinations Secretary, Mathematics	
	Gideon Itute	Examination Secretary, Chemistry	
	Mukhatar Abdi Ogle	Coordinator – National Assessment Centre and Exchange Programs	
	Paul Wasanga	Council Secretary/Chief Executive Officer	
Kenya National Union of Teachers	David Okuta Osiany	Secretary General	
	Samson Kaguma	First Vice-National Chairman	
	John Kennedy Obalah	Executive Officer	
Kenya Private Sector Alliance	Anthony Wanjohi Weru	Programs Officer	
Kenya Technical Teachers College	Yona Okidia	Head of Computer Studies Department	
	Raphael Onyango	Head of Mathematics Department	
	Bernard Njunguna	Lecturer (Chemistry) and former Head of the SMASSE INSETI unit	

	Samuel Murage Macua	Deputy Principal	
Kenyatta University	Michael Waititu	Lecturer, Department of Educational Communication and Technology	
	Ibrahim Oanda	Lecturer, Education Foundation	
Teachers Service Commission	Mary Rotich	Deputy Director, Post Primary Staffing	
	H. Farah Abdirizak	Assistant Director, Post Primary Staffing	
University of Nairobi, School of Education	Genevieve Wanjala (4^{th})	Dean	
	Justus Inyega (5^{th})	Lecturer, Science Education	
	Timothy Maonga	Lecturer, Geography	
	Evanson Muriuki Muriithi (1^{st} not sure)	Lecturer, Physics Methods	
	John Thiongo Mwangi	Lecturer, Chemistry Methods	
	Arthur Wajula (2^{nd} not sure)	Lecturer, Mathematics	
	Japheth Origa (3^{rd} not sure)	Lecturer, Physics	
	Eunice Magiri Wanjie	Lecturer, Biology Methods	
University of Nairobi, Kenya Science Campus	Isaac Jumba	Deputy Principal	
	Martin Njogu Mbugua	Lecturer, Chemistry Department	
	Grace Mzee	Assistant Registrar	
Kenya Institute of Education	Lydia Nzomo	Director/CEO	
Kenya Union of Post-Primary Education Teachers	Akelo Misori	Secretary-General	
Nairobi School	Cleophas Tirop	Principal, Chairman of the Kenya Secondary School Heads Association	
	Peter Rugand	Teacher, Head of Physics Department	
Uwezo East Africa	Sara Ruto	Regional Manager	
Center for Math, Science and	Cecilia Ngetich	Director	

Technology in Africa (CEMASTEA)			
Rwanda Math and Science Secondary Education Interviewees			
Institution	Interviewee's Name	Interviewee's Title	Picture
Private Sector Federation	Robert Bayigamba	Chairman	
	Antoine Manzi	Director of Employment	
Kigali Institute of Education	Dr. Jean de Dieu Baziruwiha	Dean, Faculty of Sciences, Senior Lecturer in Physics	
	Daniel Iyamuremye	Lecturer of Chemistry, Specialist of inorganic chemistry	
	Pheneas Nkundabakura	Lecturer of Physics, astro-physics specialist	
	Jeauaquim	Lecturer of Mathematics	
	Edwish	Lecturer of Chemistry	
	Gakwerere Francois	Lecturer of Physics	

Ministry of Education, Directorate of Science, Technology, and Research	Dr. Christine-Marie Gasingirwa	Director General Science, Technology, and Research	
Rwanda National Examinations Council	Peter Gasinzigwa Gatare	Director of Examinations	
	Jean Pierre Nsengimana	Maths Subject Specialist	
Formerly Workplace Development Authority (WDA); Currently UNIDO	Mtatiro Senseri	Entrepreneurship Expert	
Japan International Cooperation Agency	Miho Takahashi	Project Coordinator	
Riviera Secondary School	Anthony Cooke	Principal	
	John Baptist Luwaga	Dean of Students and Teacher	
Elena Guerra Secondary School	Willy Nsobiyumua, S4, taking mathematics, physics, computer science Alida Umohoza, S2, taking all subjects Odeth Uurella, S1, taking all subjects Sylvie Mikasano	Secondary school students	

	Umutesi, S2, taking all subjects		
Elena Guerra Secondary School	Syevste Haguminshuti, Math and physics teacher Josias Nteziryinaya, Math teacher Eric Munyanganizi, Physics teacher Prosper Irakoze, Computer science teacher	Secondary school M&S teachers	
Ecole Autonome Secondary School of Butare (EAB)	Joseph Nehbonimka, S5 Abudallah Hassan, S4 Aullyah Teta Gurya, S4 Jeanine Nyiraushuti, S5 Ismael Awak-Ayom, S6 Rachel Mamijinette Kabamba Uwase, S6	Secondary school M&S students	
Ecole Autonome Secondary School of Butare (EAB)	Basile Nsekuje, Director of Studies Justin Bahati, Biology Teacher Sylvestra Munyentwari, Chemistry Teacher Babone Rusagar, Math Teacher Leoncie Niyongira, Biology Teacher	Secondary school M&S teachers	
National University of Rwanda	Mageza Celestin	Lecturer and Head of Department of Physics, Faculty of Science, NUR; President of the Board at EAB secondary school	

Tanzania Math and Science Secondary Education

Interviewees

Institution	Interviewee's Name	Interviewee's Title	Picture
Agape Secondary School	Rabsen S. Fungo	Headmaster and Teacher	
	Jacob Gasper Soka	Form 4 student	
	Ommry Bakamari Kumkana	Form 4 student	
	Richard Mbembela	Chemistry and Biology Teacher	
	Liberatus Sadala	Chemistry and Biology Teacher	
	Allen Lupagaro	Chemistry and Biology Teacher	
	Geoffrey Mahenge	Physics and Mathematics Teacher	
Agency for the Development of Education Management (ADEM)	Mr. Siston Masaja	Tutor, Education Management in Planning and Economics,	
Commission for Science and Technology (CoSTech)	Dr. Raphael Mmasi	Director of Information and Documentation	
Haki Elimu	Anastazia Rugaba	Program Officer: Media	
Independent Education Consultant	Nderakindo Kessy		
Japanese International Cooperation Agency (JICA)	Msuya M. Mariango	In-House Consultant: Social Development Sector	
	Emiko Nishimura	Representative	
	Gomi Kayoko	JOCV Coordinator	
Kawe Secondary School	Annette Nara	Headmistress	
Marian Girls High School, Bagamoyo	Mr. Samuel John Mwita	Mathematics and Physics Secondary School Teacher	

Ministry of Community Development, Gender and Children	Mr. Dionis Ndamgoba	Principal Education Officer	
Ministry of Science, Technology and Research	Dr. Raphael Chibunda	Assistant Director: Research and Development	
	Mrs. Blandina J.M. Mdoe-Mkayula	Principal Education Officer	
MOEVT – Department of Secondary Education	Ms. Dorothy Mwaluko	Science Teacher; Education Officer	
	Mr. Elia Kibga	Principal Education Officer	
MOEVT – Teacher Education Department	Mr. Nicholaus Moshi		
	Mr. Bakari G. Issa	Principal Education Officer	
	Andrew L. Binde	Assistant Director	
National Council for Technical Education (NACTE)	Mr. Maggila		
	Primus D. Nkwera	Deputy Secretary: Information, Research and Development	
	Timothy N.P. Manyaga	Deputy Executive Secretary: Registration and Accreditation	
	SOMEONE ELSE		
National Examinations Council of Tanzania (NECTA)	Patrick Mtepa; Margaret Njau; Ladislaus Lutege; Angela Kitali	Examinations Officer, Physics Coordinator; Examinations Officer, Math Coordinator; Examinations Officer, Chemistry Coordinator; Head of Examinations Department	
Paradigms	Mr. Mringo	Executive Chairman	

Secondary School	Mury Yusuf	Mathematics and Chemistry Teacher	
	Oras J.M.	Mathematics and Physics Teacher	
	Mbezi A. Mbezi	Mathematics and Geography Teacher	
	Janepher Barrett	Chemistry Teacher	
	Kitokesya Kwame	Mathematics and Physics Teacher	
Tanzama Pipelines	Mzonya Ndaganza	Maintenance Engineer	
Tanzania Association of Managers and Owners of Non-Governmental Schools and Colleges (TAMONGSCO)	Benjamin Nkonya	Secretary General	
Tanzania Broadcasting Corporation	Mr. Jacob Gabriel Nduye	Principal Program Producer	
Tanzania Education Authority (TEA)	Mrs. Anne T. Mlimuka	Senior Funds Allocation Officer	
	Mr. Juma O.R. Mkude	Education Manager	
Tanzania Education Network (TEN/MET)	Mr. Anthony Henry Mwakibinga	Program Officer: Capacity Development and Innovation	
Tanzania Higher Learning Institutes Student Organization (TAHLISO)	Lawrence Hodges Mwatimwa	Mass Communicator (Current); Former President of the Student Organization, Tumaini University; Former Commissioner, TZ Higher Learning Institutes Student Organization	
Tanzania Institute of Education	Angela Kataboro	Director: Curriculum Development and Review	
	Juliana B.R. Mosi	Director: Center for Curriculum Training	
	Makoye J.N. Wangeleja	Director: Research, Information and Publication	
University of Dar-es-	Dr. Mahera +		

Salaam	colleagues		
	Dr. Wilson Mahera Charles	Mathematics Lecturer, USDM; Chairman of Panel of Mathematics; TIE	
	Dr. Christian Baruka Alphonce	Mathematics Senior Lecturer	
	Dr. Matti Heilio	Professor; Coordinator of MS programme in Technomathematics and Technical Physics at Lappeenranta University of Technology, Finland	
University of Dar-es-Salaam	Dr. Hillary Dachi	Director of the Center for Educational Research and Professional Development	

Uganda Math and Science Secondary Education Interviewees

Institution	Interviewee's Name	Interviewee's Title	Picture
Education Service Commission	John Geoffrey Mbabazi	Secretary	
Luzira Secondary School	Olive Kyohere	Head Teacher	
Kampala City Council Education Department	Charles Masaba	Deputy Director of Education	
King's College Budo	Patrick Bakka Male	Head Teacher	
Makerere University	Charles Halonda-Funa	Workforce Development Coordinator, College of Computing and Information Sciences	
	Mary Goretti Nakabugo	Senior Lecturer, Department of Curriculum,	

		Teaching, and Media, School of Education	
	Dr. Joseph Oonyu	Deputy Dean, Department of Science and Teacher Education, School of Education	
	Charles Opolot-Okurut	Associate Professor, Department of Science, Technical, and Vocational Education, School of Education	
Ministry of Education and Sports	Florence B. Sembatya Musinguzi	Principal Education Officer, Secondary Education Department	
	Nsumba Lyazi	Commissioner of Private Schools	
	Mary K. Etete Gunteese	Senior Education Officer, Secondary Department (Gov't)—works with SESEMAT	
	Kedrace Turyagenda	Commissioner, Secondary Education Standards	
Ministry of Education and Sports, Directorate of Industrial Training	Ethel Kyobe	Deputy Director, Qualifications Standards	
National Curriculum Development Center	Connie Kateeba	Director	
	Remegious Baare	Senior Specialist; Secondary Math Director	
NTC [National Teacher's College] Kaliro	Emmanuel Akiiki Ahumuza	ICT Specialist/Lecturer	
	Robert Bagarhama	Senior Registrar	
	V.G. Egonyu	Principal	
	Batemya Iraalya	Deputy Principal	

	Richard Opio	Bursar	
Our Lady of Good Counsel Secondary School	Thereza Mary Obbo	Head Teacher	
Private Sector Foundation	Sarah K.Kabasinguzi	Policy Analyst, Advocacy	
	Moses Ogwal	Director, Policy and Advocacy	
SESEMAT (Secondary Science and Mathematics Teachers' Program)	Paul Musoke	National Trainer, Physics	
	Pamela Mbabazi	National Trainer, Physics	
	Emmy Ssemuwemba	National Trainer, Biology	
	Motoe Nakajima	Technical Advisor, JICA	
Uganda Manufacturers Association	Mubaraka Nkuutu Kirunda	Director, Membership Services	
	Andrew Luzze Kaggwa	Manager, Policy Research & Advocacy	
	T. S. Mukasa	Trade Fair Manager	
Uganda National Academy of Sciences	Paul Mugambi	President	
Uganda National Chamber of Commerce & Industry	Cissy Kengoro	Research & Trade Policy Officer	
	Janepher Sambaga	Head of Lobby & Advocacy Department	
	Stephen Rugumba Wakame	Head of Membership Services; Coordinator, IBF (International Business Forum)	
	Betty Walugere	Accountant	
Uganda National Council for Science and Technology	Ismail Barugahara	Assistant Executive Secretary	
Uganda National Examinations Board	Sylvia Acana	Principal Examinations Officer, National Assessment	

		of Progress in Education (NAPE)	
	Joyce Awor Ebal	Examinations Officer, Test Development	
	Josephine Othiengo Mutonyi	Examinations Officer, Secondary Examinations Department	
	Margaret Namakoye	Senior Examinations Officer, Test Development	
	Daniel Okrich Odongo	Deputy Secretary, Secondary School Examinations	
	Amos Opaman	Assistant Secretary	
Uganda National Teachers Union	Margaret Rwabushaija	National Chairperson	
	Teopista Birungi Mayanja	General Secretary	
	Pedison Bbaale	Deputy General Secretary-Administration	

IV. Country-based Secondary Education Indicators

The Big Picture: Education Indicators					
	Rwanda	Tanzania	Uganda	Kenya	Burundi
Public spending on education, total (% of GDP)[i]	4.1 (2008)	6.8 (2008)	3.2 (2009)	7.0 (2006)	8.3 (2009)
Public spending on education, total (% of government expenditure)[ii] [iii]	20.4 (2008, WB)	27.5 (2008)	15.0 (2009, WB)	18 (2005, UNESCO)	23.4 (2009, WB)
Distribution of public expenditure per level (%) (primary/secondary/tertiary/unknown)[iv]	42/27/25/5 (2008)		61/26/11/2 (2008)	55/27/16/3 (2008)	49/25/23/3 (2008)
Public expenditure per student, tertiary (% of GDP per capita)[v]	222.8 (2008)		105.4 (2008)		520.4 (2009)

Public expenditure per student, secondary (% of GDP per capita)[vi]	34.3 (2008)	18.8 (2008)	21.2 (2009)	21.2 (2006)	59.4 (2009)
Expenditure on learning materials, primary (% of total public expenditure)[vii]	10.8 (2008)		1.7 (2009)		5.5 (2009)
Expenditure on learning materials, secondary (% of total public expenditure)[viii]	5.0 (2008)				0.7 (2006)
Average household expenditure on secondary education (fees)[ix]			(in UShs, 2006): all public schools - 125,296; public day schools - 72,187; private schools - 163,120		
Public expenditure per student, primary (% of GDP per capita)[x]	8.2 (2008)	22.1 (2008)	7.3 (2008)	22.4 (2006)	21.1 (2009)
Enrollment in private institutions as % of total enrollment, primary[xi]	2.5 (2009)	1.5 (2009)	13.4 (2009)	10.6 (2009)	1.1 (2009)
Enrollment in private institutions as % of total enrollment, secondary[xii]	31.9 (2009)	11.1 (2009)	51.5 (2008)	12.7 (2009)	8.8 (2009)
Transition rate between primary and secondary education (%)[xiii xiv]	95 (2009, EAC)	50 (2009, EAC) 36 (2008, UNESCO)	72 (2007, EAC) 57 (2008, UNESCO)	67 (2009, EAC)	32 (2009, EAC) 36 (2008, UNESCO)
Age group, secondary[xv]	13 to 18	14 to 19	13 to 18	12 to 17	13 to 19

Compulsory secondary education[xvi]	3 years (out of 6)	none (out of 6)	none (out of 6)	2 years (out of 6)	none (out of 7)
Primary enrollment (% gross)[xvii xviii]	151 (2009, WB) 129 (2009, EAC)	105 (2009, WB) 106 (2010, EAC)	122 (2009, WB) 133 (2009, EAC)	113 (2009, WB) 110 (2009, EAC)	147 (2009, WB) 130 (2009, EAC)
Primary enrollment (% net)[xix xx]	96 (2008, WB) 93 (2009, EAC)	96 (2009, WB) 95 (2010, EAC)	92 (2009, WB) 108 (2009, WB)	83 (2009, WB) 93 (2009, EAC)	99 (2009, WB) 94 (2009, EAC)
Secondary enrollment (% gross)[xxi xxii]	27 (2009, WB) 26 (2009, EAC)	27 (2009, WB) 34 (2010, EAC)	27 (2009, WB) 28 (2009, EAC)	59 (2009, WB) 45 (2009, EAC)	21 (2009, WB) 20 (2009, EAC)
Secondary enrollment (% net)[xxiii xxiv]	13 (2009, EAC)	30 (2010, EAC)	22 (2008, WB) 24 (2009, EAC)	50 (2008, WB) 36 (2009, EAC)	9 (2007, WB) 13 (2009, EAC)
Tertiary enrollment (% gross)[xxv]	4.8 (2009)		4.1 (2009)	4.1 (2009)	2.7 (2009)
Primary completion rate (%)[xxvi]	75 (2009)	69 (2009)	38 (2006)	83 (2009)	48 (2009)
Secondary completion rate (%)[xxvii]	25 (2008)			89 (2008)	76 (2008)
School life expectancy (primary/secondary)[xxviii]	9.3/1.6 (2009)	7.4/--- (2009)	8.8/1.7 (2009)	7.1/3.6 (2009)	8.8/1.5 (2009)
Percentage of repeaters in primary school [xxix]	14.8 (2009)	2.4 (2009)	13.9 (2009)		32.3 (2009)
Percentage of repeaters in secondary school [xxx]		1.7 (2009)	2.1 (2009)		20.9 (2009)
Dropout rate, primary[xxxi]		26.1 (2008)	67.6 (2006)		34.6 (2008)
Student to teacher ratio, primary[xxxii xxxiii]	68.3 (2009, WB) 63 (2009, EAC)	53.7 (2009, WB) 54 (2009, EAC)	49.3 (2009, WB) 49 (2009, EAC)	46.8 (2009, WB) 52 (2009, EAC)	51.4 (2009, WB) 82 (2009, EAC)
Student to teacher ratio, secondary[xxxiv xxxv]	22.6 (2009, WB) 32 (2009, EAC)	35.2 (2009, WB) 43 (2009, EAC)	18.1 (2009, WB) 18 (2009, EAC)	29.7 (2009, WB) 31 (2009, EAC)	26.5 (2009, WB) 58 (2009, EAC)
Student to qualified teacher ratio					
Student to classroom ratio, secondary[xxxvi]	45 (2008)	40 (2007)	36 (2008)	36 (2005)	60 (2008)

Student to desk ratio, secondary [xxxvii]	3 (2008)	4 (2008)			

Policy and Governance

	Rwanda	Tanzania	Uganda	Kenya	Burundi
Secondary education policy (directly addressing science/math?) [xxxviii xxxix xl xli]	Addressed in the Education Sector Strategic Plan 2010-2015 (science and technology education specified as a priority)	Secondary Education Development Program II (SEDP) 2010-2015 (no separate science/math strategy, but identified throughout as area of concern)	Education Sector Strategic Plan 2007-2015; Universal Post Primary Education and Training (UPPET) and Universal Secondary Education (USE) programs implemented in 2007 (S&T education identified as area of priority)	Addressed within the Kenya Education Sector Support Program (KESSP) (no separate science/math policy, but program does call for increased numbers of students studying science at tertiary level, as well as better supply of science materials to schools)	(no separate M&S policy)
S&E articles published per 10,000 people [xlii]	0.07 (2010)	0.13 (2010)	0.19 (2010)	0.26 (2010)	0.03 (2010)
University-industry collaboration in R&D (scale of 1-7; 1 = no collaboration, 7 = extensive collaboration) [xliiixliv]	3.6 (2009-2010)	3.4 (2009-2010)	3.4 (2009-2010)	3.8 (2009-2010)	3.21 (2008-2009)

Curricular Content

	Rwanda	Tanzania	Uganda	Kenya	Burundi

Institutions with which curriculum development responsibility is vested [xlv]	Rwanda National Curriculum Development Center	Tanzania Institute of Education (in Ministry of Education & Vocational Training)	National Curriculum Development Center	Kenya Institute of Education, under Ministry of Education	Pedagogical Bureaux
Frequency of curriculum review[xlvi]	Continuous	Every 5 years	Every 10 years for major reviews; continuous review at different education levels	Every 8 years for primary, 4 years for secondary	Depends on the availability of funds
Inclusion of private sector/industry/higher education/science voice in curriculum development or review processes (yes/no/some) [xlvii]	Some; university professors involved in design process	Some; needs assessments for curriculum design take into account the needs of other stakeholders; questionnaires and focus groups used to determine needs	Some; private sector involved in curriculum development (i.e. Uganda Manufacturer's Association)	Yes; surveys of teacher training colleges and university teachers for curriculum development; National Council for Science and Technology plays advisory role	No

Teacher Training and Professional Development

	Rwanda	Tanzania	Uganda	Kenya	Burundi
Teacher training programs (college/university-level)[xlviii]	Primary school teachers trained at Primary Teacher Training Colleges (PTTCs) after completing lower secondary education (3 years, training in all subjects); lower secondary scool teachers undergo 2-year program at erither Kavumu or Rukara	Teachers Training Colleges offer Certificates in Teacher Education (1 year) and Diplomas in Teacher Education (2 years); universities and university colleges of education offer education degrees (3 years) with specializations for secondary	Pre-service training is the most dominant method; teachers enrolled at Primary Teachers Training Colleges (PTCs), National Teaching Colleges (NTCs), or schools/faculties of education for varying periods of time	Several teacher training colleges (3 years for science, 2 years for liberal arts); in-service and pre-service levels models (mainly pre-service); 6 public universities with teacher-training programs, as well as several private colleges and universities	2 teacher training colleges (Pedagogical Lycee and Normal Section); secondary school teachers trained at University of Burundi (3 years for O-level, 5 years for A-level)

	Colleges of Education through face-to-face training begun after secondary school education; Kigali Institute of Education offers teacher training through distance education to lower secondary teachers	school teachers			
% of trained teachers, primary[xlix]	93.9 (2009)	100.0 (2009)	89.4 (2008)	96.8 (2009)	91.2 (2009)
% of trained teachers, secondary[l]	53.4 (2007)			92.8 (2009)	56.2 (2009)
Educational attainment of teachers, secondary (by grade, % of total secondary teaching force[li]			Grade III - 0.4 Grade IV - 0.5 Grade V - 56 Graduate of teacher training program - 28 Untrained - 15 (Grades are O-level, lower secondary)		
Teacher salaries (primary/ lower secondary/ upper secondary) (ratio of GDP per capita, US$)[lii]	2.6/6.4/7.3 (2008)		4.7/…/… (2007)	5.3/7.6/7.6 (2004)	7.6/8.4/12.2 (2007)

Evaluations of Learning Outcomes

	Rwanda	Tanzania	Uganda	Kenya	Burundi
Standardized examinations, secondary[liii]			Annual National Assessments of Progress in Education (NAPE);		

			2010 secondary (senior 2) results: English proficiency - 67.5% math proficiency - 49.7% biology proficiency - 30.4%		
% of university students studying science/mathematics/ engineering[liv]			20 (2009)		
% enrolment in higher education (gross enrolment rate) World Bank	5%		4%	4%	3%
Employment to population ratio World Bank	80%	78%	83%	73%	84%
GDP per person employed (1990 constant dollars US$ in PPP) World Bank		$1,572	$2,527	$2,453	
Life expectancy at birth World Bank	51	56	53	55	51

VI. References

Brar, Sukhdeep; Farley, Sara E.; Hawkins, Robert; Wagner, Caroline S., "Science, Technology, and Innovation in Uganda," The World Bank (2011)

East African Community, "Treaty for the Establishment of the East African Community," Articles 5 and 102 (2007).

East African Community Secretariat, "Study on the Harmonization of the East African Education Systems and Training Curricula" (2011).

Gafiligi Uwamahoro, Clémentine, Rwayitare, Pascal, Gaparayi, André, "Pedagogical Management," School Management Teach, Ministry of Education, (2010) http://www.tsc.gov.rw/Pedagogical%20Management_2.pdf

Government of Kenya, Constituencies Development Fund website, http://www.cdf.go.ke/

Government of Kenya, *Vision 2030*, (2008).

Government of Rwanda, *Education Sector Strategic Plan 2010-2015,* (2010) http://planipolis.iiep.unesco.org/upload/Rwanda/RwandaESSP20102015.pdf

Government of Rwanda, *Vision 2020*, http://www.minecofin.gov.rw/webfm_send/1700

Government of the United Republic of Tanzania, Teacher education department website, http://www.moe.go.tz/ted/ted.html

Government of the United Republic of Tanzania, *Vision 2025*, http://www.tanzania.go.tz/vision.htm

Government of Uganda, *National Development Plan 2010/11-2014/15,* www.undp.or.ug/download.php?f=520_NDP_2010.pdf

*Kyama, Reuben, Mwaura, Naftali, "*Tanzania eLearning project bringing education to 1.5 million secondary students," *E-learning Africa News Portal, (2010)* http://www.elearning-africa.com/eLA_Newsportal/283/

Ottevanger, Wout; van den Akker; Jan, de Feiter, Leo, "Developing Science, Mathematics, and ICT Education in Sub-Saharan Africa: Patterns and Promising Practices," World Bank

Working Paper No. 101, Secondary Education in Africa, Africa Human Development Department, The World Bank (2007)
http://siteresources.worldbank.org/INTAFRREGTOPSEIA/Resources/No.7SMICT.pdf

Univeristy of Connecticut, "Teacher-centered versus learner-centered paradigms," http://assessment.uconn.edu/docs/TeacherCenteredVsLearnerCenteredParadigms.pdf

Watkins, Al, Ehst, Michael, "Science, Technology, and Innovation, Capacity Building for Sustainable Growth and Poverty Reduction," The World Bank (2008)

Weddel, Kathleen Santopietro, "Competency Based Education and Content Standards," Northern Colorado Literacy Resource Center, Colorado Department of Education (2006)
http://www.cde.state.co.us/cdeadult/download/pdf/CompetencyBasedEducation.pdf

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Country-based Indicator Citations:

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[i] World Bank, http://data.worldbank.org/indicator/SE.XPD.TOTL.GD.ZS/countries
[ii] Ibid.
[iii] UNESCO Institute for Statistics, http://stats.uis.unesco.org/unesco/TableViewer/document.aspx?ReportId=198&IF_Language=eng
[iv] Ibid.
[v] World Bank, http://data.worldbank.org/indicator/SE.XPD.TERT.PC.ZS/countries
[vi] Ibid.
[vii] UNESCO Institute for Statistics, "Appendix V: Statistical Tables," in *Financing Education in Sub-Saharan Africa: Meeting the Challenges of Expansion, Equity and Quality* (Montreal: UNESCO Institute for Statistics, 2011), http://www.uis.unesco.org/template/pdf/EducGeneral/Finance_EN_web.pdf, 127
[viii] Ibid.
[ix] Donald Winkler and Lars Sondergaard, report for Uganda Ministry of Education and Sports, *The Efficiency of Public Education in Uganda* (2008), http://info.worldbank.org/etools/docs/library/244476/day7Uganda%20Efficiency%20Study.pdf, 73
[x] World Bank, http://data.worldbank.org/indicator/SE.XPD.PRIM.PC.ZS/countries
[xi] UNESCO Institute for Statistics, *Financing Education in Sub-Saharan Africa: Meeting the Challenges of Expansion, Equity and Quality*, 115
[xii] Ibid.
[xiii] East African Community, "Indicators: Social Sectors – Education, Table 1.3F," http://www.eac.int/statistics/index.php?option=com_content&view=article&id=143&Itemid=109#education
[xiv] UNESCO Institute for Statistics, http://stats.uis.unesco.org/unesco/TableViewer/document.aspx?ReportId=198&IF_Language=eng
[xv] EFA Global Monitoring Report Team, "Annex – Table 7: Participation in Secondary Education," in *The Hidden Crisis: Armed Conflict and Education* (Paris: UNESCO, 2011), http://unesdoc.unesco.org/images/0019/001907/190743e.pdf, 322-324
[xvi] Ibid., "Annex – Table 4: Access to Primary Education," 298-300.
[xvii] World Bank, http://data.worldbank.org/indicator/SE.PRM.ENRR/countries
[xviii] East African Community, "Indicators: Social Sectors – Education, Table 1.3b," http://www.eac.int/statistics/index.php?option=com_content&view=article&id=143&Itemid=109#education
[xix] World Bank, http://data.worldbank.org/indicator/SE.PRM.NENR/countries
[xx] East African Community, "Indicators: Social Sectors – Education, Table 1.3b," http://www.eac.int/statistics/index.php?option=com_content&view=article&id=143&Itemid=109#education
[xxi] World Bank, http://data.worldbank.org/indicator/SE.SEC.ENRR/countries
[xxii] East African Community, "Indicators: Social Sectors – Education, Table 1.3c," http://www.eac.int/statistics/index.php?option=com_content&view=article&id=143&Itemid=109#education
[xxiii] World Bank, http://data.worldbank.org/indicator/SE.SEC.NENR/countries
[xxiv] East African Community, "Indicators: Social Sectors – Education, Table 1.3c," http://www.eac.int/statistics/index.php?option=com_content&view=article&id=143&Itemid=109#education
[xxv] World Bank, http://go.worldbank.org/85XM5TBQA0
[xxvi] East African Community, "Indicators: Social Sectors – Education, Table 1.3e," http://www.eac.int/statistics/index.php?option=com_content&view=article&id=143&Itemid=109#education

[xxvii] Ibid.

[xxviii] UNESCO Institute for Statistics, *Financing Education in Sub-Saharan Africa: Meeting the Challenges of Expansion, Equity and Quality*, 116

[xxix] World Bank, http://go.worldbank.org/85XM5TBQA0

[xxx] Ibid.

[xxxi] Ibid.

[xxxii] Ibid.

[xxxiii] East African Community, "Indicators: Social Sectors – Education, Table 1.3d," http://www.eac.int/statistics/index.php?option=com_content&view=article&id=143&Itemid=109#education

[xxxiv] World Bank, http://go.worldbank.org/85XM5TBQA0

[xxxv] East African Community, "Indicators: Social Sectors – Education, Table 1.3d," http://www.eac.int/statistics/index.php?option=com_content&view=article&id=143&Itemid=109#education

[xxxvi] Ibid.

[xxxvii] Ibid.

[xxxviii] Republic of Rwanda Ministry of Education, *Rwanda Education Sector Strategic Plan 2010-2015* (2010), http:/mineduc.gov.rw/IMG/pdf/ESSP.pdf, passim

[xxxix] United Republic of Tanzania Ministry of Education and Vocational Training, *Secondary Education Development Programme II (July 2010-June 2015* (Final Draft, 2010), http://moe.go.tz/PDF/SEDP%20II-%20FINAL%20DRAFT%20-%2023%20JUNE%202010.pdf, passim

[xl] Republic of Uganda Ministry of Education and Sports, *Revised Education Sector Strategic Plan, 2007-2015*, (2008), http://planipolis.iiep.unesco.org/upload/Uganda/UgandaMoESStrategicplan.pdf, passim

[xli] Republic of Kenya Ministry of Education Science and Technology, *Kenya Education Sector Support Programme 2005-2010* (2005), http://planipolis.iiep.unesco.org/upload/Kenya/Kenya%20KESSP%20FINAL%202005.pdf, passim

[xlii] Data from Thomas Reuters' Web of Knowledge, http://wokinfo.com

[xliii] Klaus Schwab, editor, *The Global Competitiveness Report 2010-2011* (Geneva: World Economic Forum, 2010), http://www3.weforum.org/docs/WEF_GlobalCompetitivenessReport_2010-11.pdf, 491.

[xliv] Soumitra Dutta and Irene Mia, editors, *The Global Information Technology Report 2009-2010: ICT for Sustainability* (Geneva: World Economic Forum, 2010), 368

[xlv] Inter-University Council for East Africa, *Study on the Harmonization of the East African Education Systems* (2009), http://dl.dropbox.com/u/14506599/Harmonization%20of%20EA%20Education%20Systems.pdf, 84

[xlvi] Ibid, 85

[xlvii] Interviews with various stakeholders

[xlviii] Inter-University Council for East Africa, 64-68

[xlix] World Bank, http://go.worldbank.org/85XM5TBQA0

[l] World Bank, http://go.worldbank.org/85XM5TBQA0

[li] Aidan Mulkeen, David W. Chapman, Joan G. DeJaeghere, and Elizabeth Lu, *Recruiting, Retaining, and Retraining Secondary School Teachers and Principals in Sub-Saharan Africa* (Washington: The International Bank for Reconstruction and Development/The World Bank, 2007), http://siteresources.worldbank.org/INTAFRREGTOPSEIA/Resources/No.4Teachers.pdf, 11

[lii] UNESCO Institute for Statistics, *Financing Education in Sub-Saharan Africa: Meeting the Challenges of Expansion, Equity and Quality*, 108

[liii] National Assessment of Progress in Education, Uganda National Examinations Board, *The Achievement of Senior Two Students in Uganda in Mathematics, English Language and Biology* (2010), http://dl.dropbox.com/u/14506599/Uganda%20Achievement%20of%20Senior%202%20Students%20in%20English%20Math%20and%20Biology.pdf, xi

[liv] Uganda National Council for Science and Technology, *Science, Technology and Innovation: Uganda's Status Report 2008/2009* (2010), http://www.uncst.go.ug/dmdocuments/Uganda%20STI%20Status%20Report%20for%20Fiscal%20Year%202008-2009%20%20final%20version%20for%20publication.pdf, iii