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Strategic Policy for National Science, Technology and Mathematics Education

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1. INTRODUCTION

Science, technology and mathematics (STM) is critical for the quality of education, from the adoption of common internationally benchmarked standards to better teacher preparation and enhanced coordination across the entire education system. STM is a focus area for the Ethiopian government and a manifestation of the country's overall development endeavours. The government stresses a multidisciplinary approach to better preparing students in STM subjects and increasing the quantity and quality of post-secondary graduates prepared for STM occupations.

The Ethiopian government's motivation behind this new emphasis is to produce students versed in STM, with skills in scientific thinking and logical reasoning, and to promote sufficient and quality graduates fit to work in the country's rapidly growing economy, manufacturing industry and construction market.

To realize these intentions, politicians, education leaders and policymakers at all levels have called for a new emphasis on STM education (STME) in the nation's schools, from pre-primary level through to higher education.

Providing students with sufficient background in literacy and numeracy, and in the processing skills of science backed up with a proper technological knowledge base, is expected to build up a literate and numerate citizenry who will be committed to nation building and national development. In this respect, there is a strong consensus among key actors that the country needs to have a national strategic policy for STME, which is a means towards achieving the above stated far reaching goals.

This National Strategic Policy for STME has been developed with the above notion, considering the range of preschool up to higher education. This directly links and contributes to the objectives stated in the Growth and Transformation Plan II (GTP-II), the Education Sector Development Programmes V (ESDP-V) and the document Climate Resilience Green Economy (CRGE), and can be further adapted in the form of a strategy and action plan at the national and regional levels.

Ministers, regional education bureau's staff and regional education leaders can use this guide to further the implementation of STME agendas, and direct practical courses of action to enhance quality. Assuming a focus on STME does not set a new direction for the education system but reinforces the efforts already underway towards meeting the quality and quantity of the 70:30 professional mix in higher education (with 70% of students enrolled in science and technology and 30% in social sciences), and to get primary and secondary education, including technical and vocational education and training (TVET), on track to feed into this aim.

A further emphasis of this strategic policy is on developing human resources for the high-tech knowledge economy.

2. STME IN ETHIOPIA

Ethiopia has been a member of SMASE-Africa since 2007, a regional association for the Strengthening of Mathematics and Science Education, where African countries exchange skills, experience and issues in teacher education in mathematics and science. Consequently, the Ethiopian Government has established the Centre for Strengthening Mathematics and Science Education in Ethiopia (CSMASEE) under the Federal Ministry of Education (MoE), which is responsible for science and mathematics education.

The Education and Training Policy (ETP) and ESDPs state that education in science and mathematics is a major component determining the level of prosperity and welfare of the people and the nation. The Ethiopian Government has outlined a number of step-by-step guidelines and strategies to deal with outstanding issues regarding STME.

Nevertheless, results at both Grades 4 and 8, and across the years, are still below the national standards set by the MoE, and they do not show improvement across years and as the grade level increases. The Ethiopian education system has gone through several reforms, including the launch of a General Education Quality Improvement Program (GEQIP) with the objective of improving the quality of education at all levels, with a specific focus on improving learning conditions and strengthening institutions. The efforts undertaken by the government are promising, but need to be guided by a strategic policy that can direct overall change and improvement, including the use of information and communication technology (ICT) in education.

Global experiences reveal the necessity of having a clearly defined framework to guide STME. Moreover, Ethiopia could be a pioneer country in setting and implementing a fully-fledged and standalone STME strategic policy. Irrespective of the tireless efforts of the Ethiopian Government and the MoE, the quality level of education in STM subjects is still in need of improvement.

This strategic policy is expected to direct plans and actions for the growing nation through the collaborative efforts of all stakeholders. There is a need to make science and mathematics learning part of daily life and fun in its own right. Utilizing technology to advance learning and back development endeavours is of paramount importance. This will assist in managing efforts towards achieving the government's intentions for human development in terms of creating an educated workforce that will be fit for the country's developing economy.

3. CHALLENGES OF AND RATIONALE FOR STME IN ETHIOPIA

There is a growing need for a highly trained pool of 'quality' experts specialized in STM disciplines, as Ethiopia is currently undergoing rapid development. However, there are challenges to attaining this goal, including low achievement, negative perceptions, an incompatible curriculum and pedagogy, limited facilities and equipment, unfeasible assessment practices, and a mismatch between STM and local values and culture.

3.1. CHALLENGES AND ISSUES OF STME IN ETHIOPIA

In a growing economy such as Ethiopia's, there is a need for advanced STME. However, there are challenges that hamper its proper application and utilization.

- Current STME is rooted largely in Western history and culture with a pedagogical focus on achieving transformative impacts through creativity, innovation and problem solving, which does not fit with the Ethiopian pedagogical focus on rote memorization and recall goal.
- There is a mismatch between what is needed and what is taking place in terms of STME, as a consequence of an emphasis on content transmission in the training of teachers at the expense of the pedagogic training in the skills required to teach science and mathematics.
- There is weak overall organization to ensure that STM is seen by students as natural, relevant, fun to learn and attractive. STME is dominated by explanatory and prescriptive pedagogy focused on transformative rules and formulas, undermining innovation and creativity.
- Large class sizes, unequipped laboratories and poorly written manuals and guidelines that do not support innovation and creativity.
- There is a budget shortage for purchasing experimental resources, funding fieldtrips, etc.
- There is an absence of extracurricular activities such as zoos, science centres, museums and children's centres, which would allow students to put puzzles together, listen to lectures, play games, watch videos, etc.
- There is a lack of research-based STM learning opportunities.

- There is limited provision of and access to technology, including hardware and other apparatus, accompanied by the appropriate software.
- There is a lack of STM integration that could enhance rapid learning, adaptation and the utilization of effective foreign technologies.
- There is incompetent training, preparation and professional development of both pre-service and in-service pedagogical staff.
- There is limited awareness and involvement of the community in STM.

3.2. RATIONALE FOR STME IN ETHIOPIA

Ethiopia has witnessed rapid and double digit economic growth for over a decade. After finalizing the first GTP, the Ethiopian Government launched its second GTP (2015-2020), aimed at boosting its economy and transforming Ethiopia into a middle-income country by 2025. The main objectives of the second GTP are economic growth and industrialization, which require transforming the economy from one that is reliant on agriculture to one based on industry. Such an economic transformation can be achieved through the application of science, technology and innovation as the major instruments. The ESDP-V (2015/16 – 2019/20) envisions the application of science, technology and innovation as the major instruments for creating wealth in the country, and they have now taken their place as the foundation for achieving the long-term vision of transforming Ethiopia into a middle-income country. The underlying assumptions of this strategic policy are, therefore, to enhance STME through contextual, innovative and creative approaches to realizing this vision for the country.

4. VISION, MISSION AND OBJECTIVES OF THE STRATEGIC POLICY

4.1. VISION

The strategic policy vision is to see the country build a well-qualified and increasingly diverse STME workforce, which can lead to sustainable development in STM-related sectors and can fulfil the country's workforce needs.

4.2. MISSION

The mission is to strengthen the knowledge base of STM, to enhance basic science research and STME from preschool to post-graduate levels, and to understand and improve STME learning and applicability.

4.3. OBJECTIVES

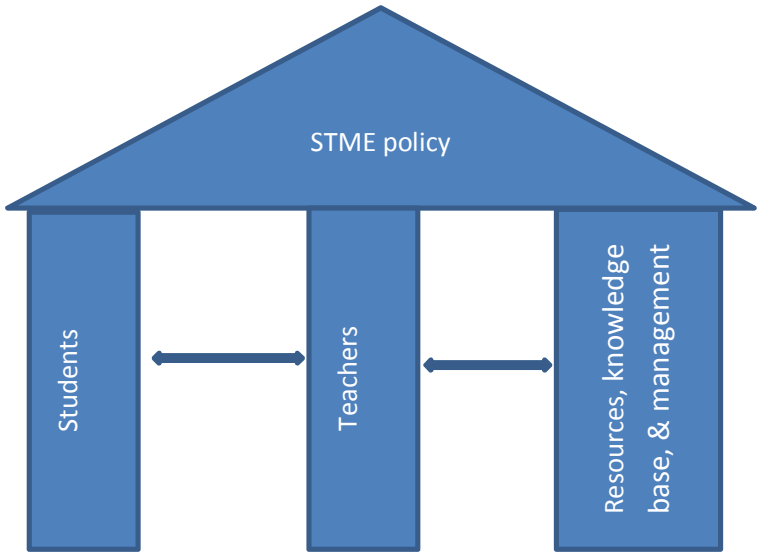
The major objectives of the strategic policy are to:

- Strengthen the pre-service training, in-service training, and continuous professional development of STM teachers.
- Improve the provision of STM resources by identifying and distributing textbooks, laboratory equipment, and other resources to schools.
- Provide students with support to improve student achievement through both in-class and supplementary programs in the short- and long-term.
- Enhance process skills in order to positively influence the teaching and learning of STM in schools.
- Improve the management of STM teaching and learning.
- Build STM as part of the culture.

5. POLICY DIRECTIONS AND IMPLEMENTATION STRATEGY

This strategic policy:

- Provides a shared roadmap to guide and ensure that the MoE and regional Education Bureaus, in collaboration with other actors such the Ministry of Science and Technology (MoST), have the best potential to make a substantial impact in key priority areas.
- Centres its foundation on the fact that teachers and students are the primary actors in STME, supported by, but not entirely dependent on, resources, and influenced by a range of learning environment factors and role players.
- Assumes that the nature of the teaching and learning behaviour of teachers and students determines the success of any education system.
- Assumes collaborative effort among all stakeholders for the overall functioning and implementation of STME.
- Focuses on three pillars:



5.1. ESTABLISH AND ENHANCE ACCESSIBLE AND QUALITY STM TEACHING AND LEARNING

This Strategic Policy for STME recognizes the centrality of teachers, resources and the role of society in realizing its stated goals and intentions. The focus should be on identifying and sharing approaches that bring about measurable change for students, and on developing new approaches.

The important issues and strategic options regarding the establishment and enhancement of STME are as follows.

5.1.1. Curriculum Development and Revision

The curriculum and its assessment need to be up to date, and the integration of Technological Pedagogical Content Knowledge (TPCK) should be pursued for the efficient and effective delivery of STME. At the

same time, inquiry-based, practical and relevant approaches to STME teaching and learning produce the most positive outcomes.

In reviewing the current curriculum and assessment procedures, the most important issues that need to be considered include:

- Making the shift from a content-based to an analytical and synthesis approach.
- Integrating indigenous practices and skills.
- Including interactive assessment methods and systems.
- Employing informal learning to expand STM beyond the classroom.
- Considering the establishment of museums, science centres and after school programs/experiences that connect STM to everyday life and career development, and expand students' skills.
- Ensuring the integration of science fair projects within the school day, implemented both by schools and the local MoE.
- Promoting student-led STME exhibits, combined with competition elements to reward the best submissions.

5.1.2. Building the Indispensable Role of Teachers in STME

The quality of STME in the school system is heavily dependent upon teachers' competencies. This can be achieved by recruiting the right people to become teachers and offering an ongoing process of professional development.

5.1.2.1. Building a Strong Teacher Profession

- Marketize and incentivize STM teaching.
- Establish centres that help teachers learn from daily activities and informal knowledge.
- Give teachers practical support such as overtime pay, workplace insurance, etc.
- Develop common core standards for innovative approaches that teacher education institutions will be required to meet.
- Strengthen existing pre-service and in-service teacher education.

5.1.2.2. Instructional Skills, Content Mastery and Attitude

- Boost the morale, aspirations, commitment and enjoyment of teachers through award mechanisms and incentives.
- Establish and expand zoos, science centres, museums, children's centres, etc. to encourage scientific literacy.
- Establish community organizations and institutions where teachers and students can regularly go to interact and create 'science for fun' activities.
- Provide excellent apprenticeship opportunities for teachers and promote a positive attitude towards STME in society.

5.1.2.3. Managing and Measuring Teacher Competence

- Install systems and processes that enable effective research, monitoring and evaluation.
- Provide tailored interventions to scale-up teacher competence.

5.1.3. The Strategy for STM Teacher Pre-Service Education and Training

- Revisit ongoing teacher education to include real science and mathematics, integrate technology, and include an out-of-school knowledge base in teacher training.
- Design standards for all higher education institutions (HEIs) to ensure a minimum level of competence in teaching.
- Commission a committee from the MoE, local HEIs and expert stakeholders to ensure that standards are met.
- Set standardized school-based induction programmes.

5.1.4. The Strategy for Teacher In-Service Education and Training (InSET)

- Provide a targeted Continuing Professional Development (CPD) programme consisting of self-reflective activities designed to improve an individuals' values, knowledge and skills.
- Support teachers' individual needs and improve professional practices at three levels: external expertise, school networks and clusters, and school-based training.
- Use ICT to enhance the implementation of existing and new policies and programs.
- Develop a teacher InSET policy, plan and consultative structure.
- Establish an STM teacher management information system.
- Strengthen the capacity to use formative assessment practices and develop a system that integrates the assessment of theoretical understanding and practical ability, to ensure that students develop good problem solving skills.
- Build up the capacity to integrate technology, content and pedagogy.
- Organize events, exhibits and conferences.
- Promote the conducting of research and the dissemination of findings.

5.1.4.4. Integrating Technology, Content and Pedagogy in Organizing STM

- Enhance innovation and creativity.
- Incorporate TPCK during teacher education.
- Nationalize School-Net effort
- Launch smart classrooms in schools.

5.2. IMPROVING STME RESOURCES

Research on school effects has generally shown a relationship, although modest, between educational resources and student learning. Hence, there is a need to improve STME resources that impact the quality of teaching and learning.

5.2.1. The Function of Resources in Improving STME

- Ensure the adequacy of resources at every school to improve teaching and learning.
- Make available materials for all topics included in the curriculum.
- Identify, access and use locally available materials effectively.
- Assist teachers in planning what materials to use and how to use them.
- Supply adequate spaces and tools to cater for special needs and facilitate safety and resource management.
- Promote the use of micro and small-scale kits.
- Offer opportunities for sharing resources and for using mobile resources.

- Equip all schools across the country with ICT and ensure proper storage, maintenance and use of ICT resources.

5.2.2. The Strategy for Improving STME Resources in Schools

- Develop an STM Resource Database through a comprehensive checklist of the minimum required STM resources and standards.
- Develop a regional level plan to ensure that schools satisfy the minimum requirements.
- Ensure digital literacy through the realization of a teacher/school laptop program.
- Distribute micro science kits and small-scale equipment to complement conventional large-scale facilities and laboratories.
- Enable the CSMASEE to review the situation in schools and seek to provide resources.
- Emphasize resources for students with special needs.
- Supply sufficient learning materials to all schools in the form of adequate textbooks and additional references.
- Establish regional level resource centres.
- Promote the sharing of resources, as well as adaptation and improvisation.
- Renovate and upgrade laboratories and special rooms.
- Establish STME centres at the regional/city level.
- Establish special learning centres for gifted students.

5.3. IMPROVING STME MANAGEMENT

STME requires a specialized form of management to ensure the smooth functioning of planned activities. Therefore it is essential to restructure the following structures and strategic actions, from both content and administrative perspectives.

- Develop a national framework to organize vertical and horizontal integration across content and in line with the development needs of the nation.
- Strengthen the powers vested in the CSMASEE in a way that empowers action.
- Build up a system that encourages the smooth functioning of all organs and stakeholders.

5.3.1. Reviewing and Managing the STM Educational Environment

- Establish a mandated STME institution.
- Establish regional level structures.

5.3.2. Strengthening and Capacitating the CSMASEE

- Establish a competent, accountable and transparent leadership and governance system for the CSMASEE, governed by a board that encompasses stakeholders.
- Enhance collaborative agreements between the CSMASEE and HEIs.
- Allocate a separate budget for the CSMASEE at the national and regional levels.
- Establish a joint team from the MoE, MoST, Ethiopian Science Academy and professional associations, etc.
- Align the curriculum, pedagogy and assessment at all levels with specific agencies established for this purpose.

5.3.3. Learning Culture Campaign

- Implement a campaign to encourage teachers to adopt a strong STM learning culture.
- Encourage and support teachers' regular learning activities.
- Involve the public through the establishment of science centres and museums, organizing science days and conferences, etc.
- Employ various audio-visual and print media.

5.3.4. School STME Targets

- Set targets for each grade level and incentivize schools to achieve these targets.
- Assist schools in setting targets and building the capacity to achieve them.
- Set standards of excellence that schools can aim to achieve at different levels.

6. MONITORING AND EVALUATION OF STME FUNCTIONING

- Build regular monitoring and evaluation systems at all levels.
- Strengthen capacities and mitigate problems with the view of achieving the mission and vision set out in this strategic policy.

7. POLICY IMPLEMENTATION AND PRINCIPLES

Implementation of this strategic policy will be based on the following principles:

- The MoE will take on a leadership role, including in the overall capacity building process.
- STME activities will be integrated with socio-economic activities.
- There will be a strong public-private partnership as well as collaboration with development partners.
- There will be transparency and accountability.