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# STEM Education for the Fourth Industrial Revolution (4IR) in Africa with a Focus on Generating Decent Jobs for Africa's Youth

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This policy brief is jointly prepared by the African Union Commission (AUC), the International Labour Organization (ILO), the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the United Nations Office of the Special Adviser on Africa (OSAA) within the framework of the Africa Dialogue Series 2024 (ADS 2024).

The ADS 2024 is organized by the United Nations Office of the Special Adviser on Africa (OSAA) and the African Union Permanent Observer Mission to the United Nations (AUPOM) in partnership with International Labour Organization (ILO), the International Telecommunication Union (ITU), the United Nations Economic Commission for Africa (UNECA), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the Office of the United Nations High Commissioner for Refugees (UNHCR), the United Nations Children's Fund (UNICEF) and The World Bank Group (WB).

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# 01

# Introduction

African countries have recorded important progress in advancing education-related goals and targets. The out-of-school population in sub-Saharan Africa at primary and secondary levels dropped from 44% in 2000 to 29% in 2020, while the youth literacy rate increased increased from 66% to 77.5%, and the adult literacy rate from 53% to 64% during this period. [1] African States have made significant commitments through the SDG4 benchmarking process. [2] to scale up results towards 2030, and the designation of 2024 by the African Union as the "Year of Education" embodies these goals. Nevertheless, structural constraints continue to represent bottlenecks that hinder the promotion of inclusive and quality education, and while gender parity has improved, progress has been slow, particularly in lower-income countries and in STEM fields. [3]

The African Union's Agenda 2063 [4] calls for inclusive growth and a skills revolution drawing on innovation, science, and technology for sustainable development and social and economic transformation across Africa. To realize this vision, the African Union's ten-year Continental Education Strategy for Africa 2016-2025 (CESA) [5] focuses on strengthening education systems on the continent to build competencies, skills, and quality human capital that can support the attainment of development objectives. The African Union Science, Technology, and Innovation Strategy for Africa

[01] UNESCO. (2024). Global Education Monitoring Report, 2023: Technology in education: a tool on whose terms? Paris, UNESCO.

[02] UNESCO Institute for Statistics, UNESCO Global Education Monitoring Report. (2024). SDG 4 scorecard progress report on national benchmarks: Focus on teachers. Paris, UNESCO.

[03] UNESCO and the African Union Commission. (2023). Education in Africa: Placing equity at the heart of policy. Continental report. Paris, UNESCO.

[04] African Union. (2015). Agenda 2063: The Africa we want. Addis Ababa, African Union.

[05] African Union. (2015). Continental education strategy for Africa 2016-2025. Addis Ababa, African Union.

(STISA-24) [6] also drives action in this area. Similarly, the Continental Strategy for TVET provides a comprehensive framework to foster youth entrepreneurship, innovation, and youth employment through skills development. The Second Ten Year Implementation Plan of Agenda 2063, underlines the opportunity to boost the empowerment and productivity of African citizens, in particular by harnessing the power of science and innovation (Target 6.1) .[7]

Education, and STEM education, in particular, is a critical engine of inclusive growth and sustainable development. Countries with high STEM human capital are competitive, and productive and experience high economic growth. [8] Expanding STEM competencies drives innovation-led and knowledge-based development through advancements in sustainable agriculture, climate adaptation, energy, infrastructure, and economies. Advancing STEM education can enable Africa to fully benefit from the Fourth Industrial Revolution (4IR) by leapfrogging traditional development pathways and opening up avenues for trade, investment, entrepreneurship, and cooperation.[9]

It is safe to say that advancing STEM education plays a catalytic role in achieving all other SDGs. Beyond the actual STEM disciplines, STEM education develops critical thinking, problem-solving skills, communication, collaboration, and digital skills. All of these skills are critical to young people in building their resilience and navigating transitions in their lives, in particular the school-to-work transition.

To realize its job creation capacity for millions of its youthful population, Africa needs to embrace STEM education at all levels. STEM-related jobs and careers are on the rise. It is estimated that Sub-Saharan Africa alone needs 2.3 million engineers to address its development challenges, including huge infrastructure projects, sustainable energy solutions, improved health care, and improved food production. [10] STEM fields are growing alongside the demand for them in the region, causing huge job opportunities that are currently outsourced from outside Africa due to a lack of investment, technology, and skilled workforce in the STEM fields.

[06] African Union (2014). Science, Technology, and Innovation Strategy for Africa 2024. Addis Ababa, African Union.

[07] African Union (2024). Second Ten-Year Implementation Plan 2024-2033. Addis Ababa

[08] Rothwell, J. (2013). The hidden STEM economy. Washington, D.C., Brookings Institution.

[09] Amegah, A. et al. (2023). Empowering Africa's future: Prioritizing STEM skills for youth and economic prosperity. World Bank Blog.

[10] Ibid

# 02

# The state of STEM education in Africa

Aligned with continental priorities, many countries have taken steps to improve the quality of STEM education at different levels of education and promote the uptake of STEM studies and careers. However, data challenges limit an assessment of progress.

While general trends in enrolment are available from periodic education statistics, there is very little information that can clearly show trends in student enrolment in STEM subjects in Africa in secondary education. [11]

Similarly, data on performance in STEM subjects are lacking. There is no cross-country assessment for STEM education at the secondary school education cycle across Africa, and country participation in sub-regional assessments of maths and science is limited at primary and secondary levels. [12]

A review of trend data of countries participating since 2003 in the Trends in International Mathematics and Science Study (TIMSS) that assesses eighth-grade students (approximately 14 years of age) achievement in mathematics and science found some improvements over time but with scores below the benchmark of 500 points (See Figure 1). [13]

Data are also limited on participation rates in STEM fields in higher education, but one report estimates that fewer than 25% of higher education students pursue STEM fields of study, of whom fewer than 30% are women. [14]

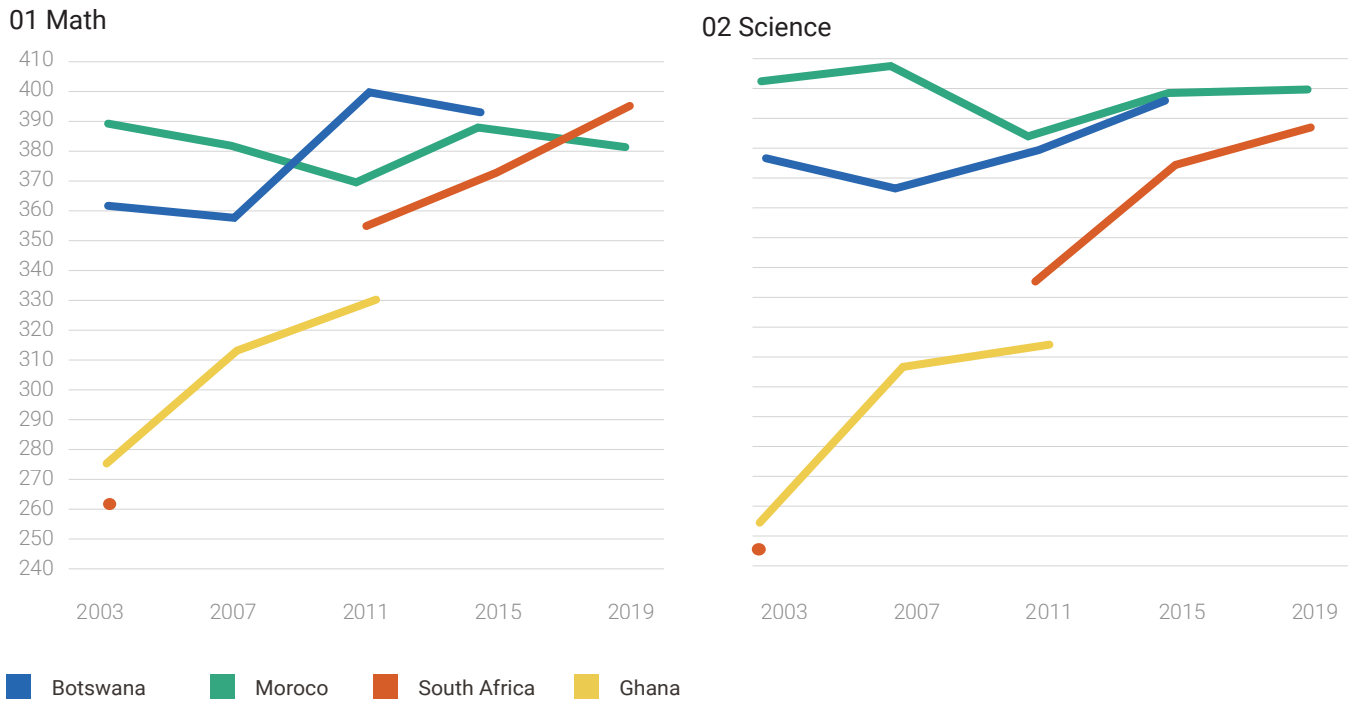
[11] Association for the Development of Education in Africa (ADEA). 2022. Development of monitoring and evaluation system for quality STEM education at the basic learning levels in Africa. Abidjan, ADEA.

[12] The most recent reports of Southern and Eastern Consortium for Monitoring Educational Quality (SEACMEQ) and Programme for the Analysis of Education Systems (PASEC) assess reading and mathematics at primary grades covering a small number of countries in Eastern, Southern and Western Africa.

[13] Association for the Development of Education in Africa (ADEA). 2022. Development of monitoring and evaluation system for quality STEM education at the basic learning levels in Africa. Abidjan, ADEA.

[14] Mutsvangwa, A. and Zezekwa, N. STEM education: A ray of hope for African countries. 10(2), Unnes Science Education Journal, 10(2), 79-89.

**Figure 1:** Performance in TIMMS at Grade 8 by country over time




***Source: IEA TIMSS and PIRLS International Study Centre, cited in: Association for the Development of Education in Africa (ADEA). 2022. Development of monitoring and evaluation system for quality STEM education at the basic learning levels in Africa. Abidjan, ADEA.***

In 17 of 21 countries with sex-disaggregated data for 2016-2018, women represented 16% or less of graduates in STEM fields. The highest proportions of women among STEM graduates can be found in North Africa, Tunisia (36.5%), and Algeria (31%), but this remains far from gender parity (see Figure 2). The greatest gaps are in engineering and Information, Communication, and Technology (ICT) studies – key for harnessing the potential of the 4IR.

Many countries have issued national science, technology, and innovation or STEM education policies, domesticating the AU STISA-2024. This includes Ethiopia [15], Nigeria [16], Rwanda [17] and South Africa [18]. Many more have sciences and mathematics within their education policies. Most national development policies in Africa also mention STEM as important for industrialization and social and economic development. [19]

Some countries have applied financial incentives to increase participation in STEM studies and careers. This includes preferential scholarships in Ethiopia for students pursuing STEM studies or in Uganda, providing monetary incentives to schools that register higher numbers of STEM students. Many governments and institutions have established STEM scholarship programmes for girls and young women, aiming to close gender gaps in STEM studies and careers. [20]

Many African countries have established STEM centres of excellence at different levels of education to develop and exemplify best practices, as can be seen, for example, in Egypt, Kenya, Rwanda, and Zimbabwe. The Centre for Mathematics, Science and Technology Education in Africa (CEMASTEA) also provides implementation support to countries to scale up such programmes. Some universities have also developed innovation hubs and incubators to support the transition into the labour market, entrepreneurship,

[15] Ministry of Education. Strategic policy for national science, technology and mathematics education. Addis Ababa, Ministry of Education.

[16] Federal Ministry of Education. 2020. National policy on science and technology education. Abuja, Federal Ministry of Education.

[17] National Council for Science and Technology (NCST). 2020. Science, technology and innovation policy. Kigali, NCST.

[18] Department of Education. 2001. National strategy for mathematics, science and technology education in general and further education and training. Pretoria, Department of Education.

[19] UN Officer of the Special Adviser on Africa (UN-OSSA). 2022. Science, technology, engineering and mathematics (STEM) as an enabler for development and peace. New York, UN-OSSA.

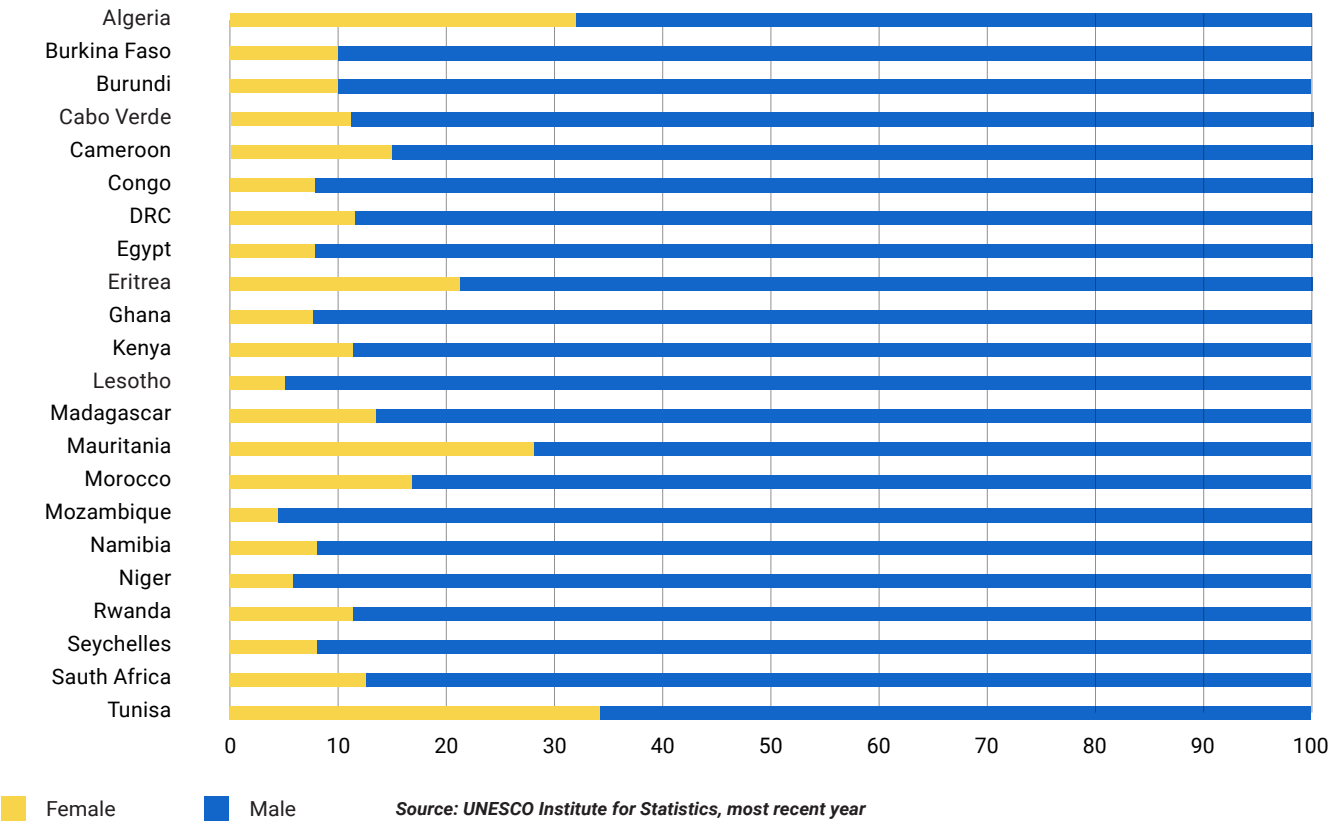
[20] See, for example, the Partnership for Skills in Applied Sciences, Engineering and Technology's Regional Scholarship and Innovation Fund, the L'Oréal-UNESCO's Sub-Saharan Africa Young Talents Programme, and the Working to Advance African Women (WAAW) foundation's STEM scholarships.

and hands-on learning.

Many African Governments have been moving toward competency-based curricula and promoting classroom-industry interface through apprenticeships and other forms of work-based learning aimed at promoting creativity and innovation and connecting to real-world realities. At least 10 countries, are implementing a competency-based curriculum which emphasizes inquiry-based learning in STEM, including in technical and vocational education and training. [21] For example, in 2019, Rwanda introduced a "new competence-based curriculum" for pre-primary up to upper secondary education, including STEM and ICT-led education. Rwanda has also invested in STEM-related infrastructure such as laboratory equipment and technology and rolled out the One-Laptop-Per-Child flagship programme. [22]

To ensure teachers and trainers are equipped with the knowledge and skills to deliver this curriculum, governments are also investing in teacher capacity development to ensure qualified STEM teachers. For example, in Cameroon, since 2016, the African Institute of Mathematical Sciences (AIMS) has been supporting teacher training programmes at pre- and in-service to deliver mathematics [23] and science to increase the pipeline of students in these fields. In South Africa, the Gauteng Primary Language and Mathematics Strategy, implemented in over 1,000 primary schools, has led to improvements in early-grade mathematics. Personalized instructional coaching, support to deliver a range of pedagogical approaches, and learning and teaching materials were successful in helping teachers adopt more effective practices. The Forum for African Women Educationalists' (FAWE) model for gender-responsive pedagogy, building teacher capacity, mentoring girls, and sensitizing key stakeholders has yielded significant results in several countries, including Burkina Faso, Eswatini, Kenya, Mali, and Mozambique. [24]

**Figure 2:** Women make up a small proportion of STEM graduates in African countries with data




***Source: UNESCO Institute for Statistics, most recent year***

[21] Kagia, R. 2023. STEM education in Africa: Risk and opportunity. Commentary. Brookings Institution website.

[22] Dugbazah, J., Glover, B., Mbuli, B. and Kungada, C. 2021. Rwanda as a model: Improving STEM education curricula in Africa. African Union Development Agency Planning and Coordination Agency NEPAD (AUDA-NEPAD) Blog.

[23] Fleisch, B., Schöer, V., Roberts, G. and Thornton, A. 2016. System-wide improvement of early-grade mathematics: New evidence from the Gauteng Primary Language and Mathematics Strategy. International Journal of Educational Development, 49, 157–174.

[24] UN Officer of the Special Adviser on Africa (UN-OSSA). 2022. Science, technology, engineering and mathematics (STEM) as an enabler for development and peace. New York, UN-OSSA.

# 03

# Challenges and opportunities for promoting STEM education for job creation and harnessing the demographic dividend.

**The large number of out-of-school children and young people out of training or those acquiring skills through informal means coupled with low levels of learning and skills development outcomes among those who are in school limit the capacity of African countries to leverage the catalytic benefits of STEM education. From 2015-2021, the out-of-school population in sub-Saharan Africa increased by 12 million. While rates have declined, 29% of the school-age population remains out of school, [25] and 86% of children already suffered from learning poverty before the COVID-19 pandemic, a figure expected to increase. [26] In many contexts, including conflict- and post-conflict situations, the focus is still on ensuring access to education and improving learning outcomes, with advancing STEM education a secondary priority. Moreover, in Africa, the percentage of young people aged 15–24 who are neither in employment, education or training ( NEET) rate has increased from 23.5% in 2015 to 26.1% in 2024, [27] signifying that more than 1 out of 5 youth are now at risk of further detaching from education, training, and the labor market.**

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**1/5**

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[25] UNESCO. (2024). Global Education Monitoring Report, 2023: Technology in education: a tool on whose terms? Paris, UNESCO.

[26] World Bank, UNICEF, FCDO, USAID, the Bill & Melinda Gates Foundation, in partnership with UNESCO. (2022). The State of Global Learning Poverty: 2022 Update. 'Learning poverty' means being unable to read and understand a simple text by age 10 - this measuring method was introduced by the World Bank in coordination with UNESCO Centre for Statistics - World Bank. 2019. Ending Learning Poverty: What Will It Take?

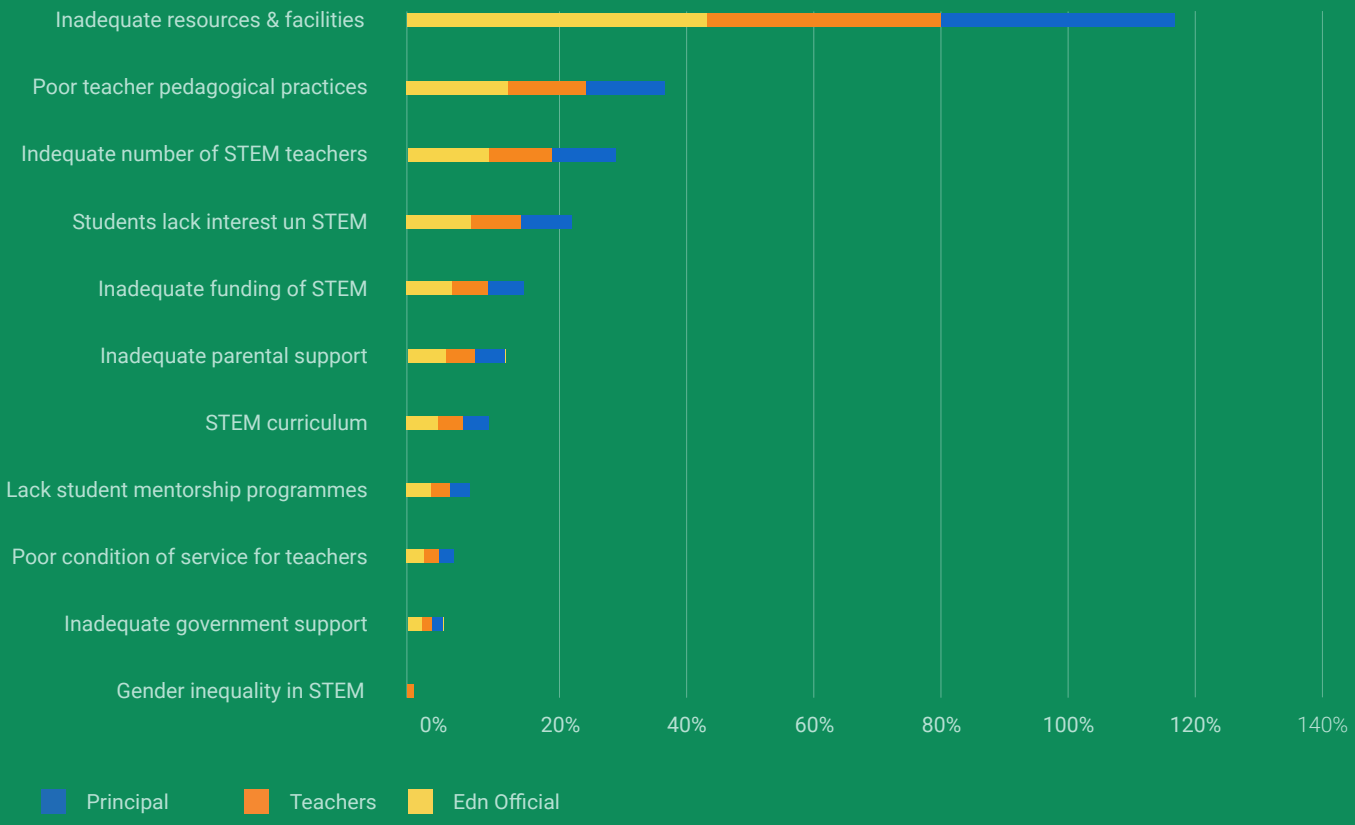
[27] ILOSTAT. 2024. SDG indicator 8.6.1 – Propostion of youth (Aged 15-14 years) not in education, employment or training (%) – Annual [Available at: https://rshiny.ilo.org/dataexplorer48/?lang=en&id=SDG_0861_SEX_RT_A]

A 2021 situation analysis undertaken by ADEA found that inadequate resources and facilities, poor teacher pedagogical practices, and an insufficient number of STEM teachers were among the key challenges to achieving quality STEM education (see Figure 3). These challenges are explored further below.

Inadequate infrastructure and resources include low access to electricity and internet connectivity.[28] Additionally, a scarcity of smart classrooms, well-equipped science laboratories, and essential educational materials hamper effective teaching and learning in STEM subjects. Challenges at the higher education level include the lack of research infrastructure, funding, and governance mechanisms to ensure quality assurance. [29]

Inadequate numbers and quality of the workforce remain a concern and are compounded by high and increasing enrolments in education. Sub-Saharan Africa is faced with significant teacher shortages: an additional 15 million additional teachers are needed for 2030, largely to meet a rapidly expanding school-aged population. [30] While some countries are projected to meet the demand for secondary teachers, including Kenya, Central African Republic, Congo, and the Gambia, many others are far behind. Moreover, there is a significant under-representation of female teachers. In Ghana, only 5% of STEM teachers in the upper grades are female. [31]

**Figure 3:** Challenges in achieving quality STEM education




***Source: Association for the Development of Education in Africa (ADEA). 2022. Development of country Policy on Provision of quality STEM Education at the basic learning levels in Africa. Abidjan, ADEA..***

[28] Adebayo, R. (n.d.) Tackling spending and inequalities to promote STEM education in Africa. UN Office of the Special Adviser on Africa website.

[29] UN Officer of the Special Adviser on Africa (UN-OSSA). (2022). Science, technology, engineering and mathematics (STEM) as an enabler for development and peace. New York, UN-OSSA.

[30] UNESCO. (2023). Global report on teachers: Addressing teacher shortages. Paris, UNESCO

[31] Kiwete, H.E.J. Education and Skills: Equipping a labor force for the future. In: Ordu, A.U. and Ntungire, n. (eds): Foresight Africa: Top Priorities for the Continent in 2023. Washington, D.C., Brookings Institution, pp. 56-81.

Far too many teachers also are insufficiently trained: only 64 per cent of primary school teachers and 50 per cent of secondary school teachers in sub-Saharan Africa have received the minimal training required. [32] Teacher professional development, both initial and continuous, in STEM fields is another challenge to be overcome.

Financial resources to advance STEM are also insufficient. Currently, sub-Saharan African countries allocate considerable resources to education, both in terms of GDP and total government expenditure, but earmarked funding for science and technology is either meagre or non-existent in many countries.[33] While policies are in place in many settings, these have yet to be met with sufficient resources to ensure relevant interventions. This is particularly the case in rural areas, where less attention and resources are devoted to the implementation of STEM education policies. Data gaps also limit the ability to strategically target funding to areas more needed to build participation, learning and retention in STEM fields. Appropriate investments in STEM, need to be grounded in predictable access to domestic resources mobilized for the education sector, emphasizing the primacy of domestic resource mobilization for African countries to get back on track to achieving the SDGs.

Growing numbers of youth in Africa are both a challenge and an opportunity. Africa has the youngest population in the world. By 2050, one in every four people on earth and more than a third of the world's young people aged 15-24 are expected to be African.[34] Converting this youth dividend into a highly skilled STEM workforce could be a game changer. [35] Through prioritizing STI and STEM education, Africa has enormous potential to transform education into a driver of structural transformation, economic diversification, and inclusive and sustainable industrialization.

Furthermore, unlocking Africa's enormous economic potential and attaining development objectives, including the SDGs and the aspirations of Agenda 2063, can only be achieved through scaled-up and targeted investment in Africa's burgeoning youth population to harness the massive potential of the continent's demographic dividend. The World Social Report 2023 underscores that Africa can become a significant engine of global economic growth if African countries implement policies that harness the historic demographic dividend. [36]

This will also be crucial for driving Africa's inclusive structural transformation and creating sufficient decent jobs in priority sectors within the continent, including in the manufacturing sector. Currently, millions of young African men and women enter the job market annually, most commonly in the agriculture and retail trade sectors, and not necessarily in ICT and STEM-related occupations. The occupational structure of employment is driven not only by the supply-side factor (i.e. the availability of skilled workforce) but also by demand-side factor (i.e. the availability of job opportunities). [37] Investment in human capital in the STEM field, therefore, must be accompanied by investment necessary for job creation in STEM-related occupations to create the demand for such human capital. Such an integrated approach that takes into account both the supply and demand sides has the potential to support skills development and youth employment in STEM-related fields and emerging technologies such as artificial intelligence (AI) solutions, and can help mitigate the risk of brain drain, translate economic growth into a meaningful reduction in poverty rates, and reduce income inequalities.

It is proposed to also examine strategies to provide up-skilling and reskilling and recognition of prior learning opportunities for young persons already part of the workforce to be able to appropriately be recognized for the skills they possess and tap into opportunities for decent jobs and continuous learning associated with the 4IR. This also necessitates a review of opportunities to engage in work-based learning, incubate entrepreneurial skills among young populations on the continent, and policies and strategies that mobilize seed capital or access to concessionary funding for start-ups.

[32] UNESCO. (2024). Global Education Monitoring Report, 2023: Technology in education: a tool on whose terms? Paris, UNESCO

[33] UN Officer of the Special Adviser on Africa (UN-OSSA). (2022). Science, technology, engineering and mathematics (STEM) as an enabler for development and peace. New York, UN-OSSA. World Economic Forum. (2024)

[34] Munyati, C. (2024). Empower youth in Africa to create jobs, growth and peace World Economic Forum website.

[35] Page, J. (2019). Harnessing Africa's youth dividend. A new approach for large-scale job creation. Washington, D.C., Brookings Institution.

[36] UN Department of Economic and Social Affairs (UN-DESA). (2023). World Social Report 2023: Leaving no one behind in an aging world, United Nations

[37] International Labor Organization (ILO). (2023). Youth skills: tackling challenges and seizing opportunities for a brighter future of work. ILO website.

# 04

# Conclusions and Policy Recommendations

Integrated and coherent policies are needed at local, national, and regional levels to recognize education and skills development as an integral part of the broader continental strategy on science, technology, and innovation. Such coherence would harness the synergies between SDG4 and other SDGs, including SDG1 on poverty [38] , SDG5 on gender equality, and SDG8 on decent work and economic growth and fully harnessing the role of education and skills development as an engine of inclusive growth and sustainable development.

Development policies, financing frameworks, and budgetary allocation/spending must reflect this strong nexus between promoting quality education and skills development, including in STEM, strengthening research and science, technology, and innovation; and creating decent jobs and expanding opportunities for the economic participation of African youth, particularly in the manufacturing sector towards advancing inclusive economic growth and sustainable development.

[38] UNESCO (2022). Education in Africa: 5 priorities: demographics, financing, inclusion, quality, employment. Paris, UNESCO.

# We also call for action in the following areas:

## 01 Policies, governance and financing:

- Anchor STEM education and skills development in policy, based on robust situation analyses of socio-economic trends and dynamics and collaboration with stakeholder groups, including the private sector, through effective governance mechanisms for social dialogue and promote dynamic linkages between education and training and the labor market.
- Develop enabling policies that aim to reduce gender and other gaps in STEM at all levels of education and training and ensure equal educational pathways and access to skills development and decent work opportunities.
- Ensure policies are linked to implementation plans with clear frameworks to monitor and evaluate impact, data collection and earmarked funding, and review these regularly for outcomes.
- Increase investment in STEM-related sectors in domestic African economies to spur demand for decent jobs and increase enrolment in STEM-related courses by young people.

## 02 Resources:

- Support the allocation of adequate and sustainable resources to meet infrastructure, equipment, and material needs in national budgets of ministries in charge of education and TVET through domestic resource allocation and other sources, including through partnerships with the private sector.
- Ensure an equitable distribution of resources to address gaps in rural areas, crisis and conflict zones, and other settings that may be marginalized and/or face resource gaps.
- Invest resources to close gender gaps in STEM, including financial support for girls' and women's participation, teacher and trainer professional development in gender-responsive pedagogy, scholarships, and other interventions.

## 03 Data:

- Collect more and better data, including intersectional data disaggregated by sex, ethnicity, ability, and other factors, to understand participation, learning, and retention in STEM fields of study and use data for planning.
- Explore the use of a wide range of data, such as labor force surveys, administrative data, and real-time big data, to better monitor occupational trends and skills demand and inform demand-driven education and training programs in STEM fields.

## 04 Curriculum and teaching, training, and learning materials:

- Link policy reform with curriculum reform and promote problem-solving, computation thinking, creativity, and integrated learning opportunities across different levels of education and training.
- In efforts to support ICT-enhanced teaching, training and learning, address gaps in technology, infrastructure, equipment and usage, including unequal access to technology in educational and vocational training processes by learners.
- Expand opportunities for career counseling and guidance to raise students' STEM aspirations, challenge existing career stereotypes, and increase academic achievement.
- Support early exposure to STEM subjects through early childhood education to strengthen student confidence in learning and stimulate children's positive disposition to these subjects.
- Adopt STEM pedagogical approaches to foster skills transferability and core competencies at TVET and higher levels for seamless transition from school to work.
- Promote apprenticeships and other forms of work-based learning in the STEM field, including through identifying skills needs, preparing occupational profiles and curricula, and developing instructional and learning materials

## 05 Teachers and teacher professional development:

- Develop holistic teacher and trainer policies aligned to national priorities on STEM education and training with a focus on professional development, care mobility and remuneration, and closing gender gaps among STEM teachers and trainers.
- Expand access to teacher and trainer professional development, initial and continuous, and support, including innovative and gender-transformative pedagogies

## 06 Partnerships:

- Promote effective partnerships between industry and TVET through social dialogue, including those for designing and implementing apprenticeships and other forms of work-based learning in the STEM field, to facilitate the acquisition of much-needed work experience and core and technical skills among youth.
- Expand partnerships with female STEM professionals to transform perceptions of women in STEM, break gender stereotypes, and expand access to mentoring, apprenticeship, and work experience programs; career support; capacity development, and networking.
- Establish partnerships and networks of universities and research institutions that can educate and train young scientists, and promote knowledge sharing and exchange across countries and disciplines.

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