K4D | Knowledge, evidence and learning for development

Benefits of STEM Education

Zenobia Ismail
University of Birmingham
4 September 2018

Question

What are the benefits of STEM education, especially in low income countries?

Contents

1. Summary
2. Rationale for STEM education
3. STEM and gender differences
4. Benefits of STEM Education
5. STEM education in Rwanda
5. References

1. Summary

The literature concurs with the general view that science, technology, engineering and mathematics (STEM) education is necessary to facilitate economic development, international competitiveness and job creation. However, the literature does not specify the particular benefits of STEM education in developing countries since the consensus is that STEM education is generally lacking in these countries. Moreover, the gender gap in STEM education is prevalent in some developed and most developing countries (UNESCO, 2017:20). However, STEM has been useful for enhancing teacher training in developing countries, stimulating innovative approaches for secondary education and aligning the demand and supply of skills (Burnett & Jayaram, 2012; Hooker, 2017). In Rwanda, engineering education has provided skilled personnel for industry and solutions for local development problems (Lwakabamba & Lujara, 2003). In addition, collaboration with Swedish universities has boosted the research capacity at the University of Rwanda (Tvedten, Byabagambi, Lindström, & Tedre , 2018).

The literature on STEM education in developing countries focuses on the challenges many young people face with regard to access to secondary and tertiary education in general as well as the gender gaps in STEM education. It therefore proposes strategies for overcoming these difficulties. Studies on STEM education usually adopt a regional focus such as Africa or Asia and therefore the reports amalgamate data from middle-income and low-income countries. There is some literature on the benefits of science and technology (as a sector) on economic growth or combating diseases such as HIV or malaria. The literature does not discuss the benefits of STEM education beyond the general view that STEM facilitates economic growth and competitiveness. Given that the literature does not address the query directly, the following approach is used in this rapid literature review: literature from developed and developing countries is used to discuss the rationale for STEM education and the key trends in this field. Statistics relating to the gender gap are presented and the impact of some programmes which aim to improve female participation in STEM in developing countries is discussed. Since much of the literature on STEM education mentions teacher training, this is discussed as a benefit of STEM education, together with meeting the demand for skills and innovations for secondary education. Case studies of STEM education projects in Rwanda, a low-income country which has prioritised education and undertaken several initiatives to improve STEM education, are used to highlight the benefits of STEM education.

The main findings are as follows:

- The rationale for investment in STEM education relates mainly to its association with improved economic outcomes (African American Institute, 2015; Williams, 2011).
- Unemployment in the Middle East and Latin America is linked to the inadequate supply of skills required by employers (Burnett & Jayaram, 2012).
- The 21st century job market requires a new set of skills, and there is more emphasis on technology skills (Voogt & Roblin, 2012).
- Across the world only 30% of female students pursue STEM related higher education studies (UNESCO, 2017).
- UNESCO (2017) regards access to STEM education for girls as a human right.
- Science Technology and Mathematics clinics in Ghana have provided training to over 40,000 girls from 1986-2010 (Bermingham & Engmann, 2012).
- Technical Vocational Education and Training (TVET) education is recommended for bridging the demand and supply of skills in Africa and Asia (Burnett & Jayaram, 2012).
- TVET is necessary at secondary school level to prepare students for self-employment and entrepreneurship (Likly et al., 2018).
- Apprenticeships and continuing education can be used to provide STEM related training to informal sector workers (Lwakabamba & Lujara, 2003).
- STEM education should address local development needs (Sohoni, 2012).
- STEM education can contribute to voluntary, informal and domestic work by enhancing knowledge of hygiene, health, and agriculture (Likly et al., 2018).

2. Rationale for STEM education

STEM education is regarded as a priority in high-, middle- and low-income countries (Burnett & Jayaram, 2012; Ohize, 2017; Ostler, 2012). However, STEM education is lagging in some parts of the world, for example in Africa, where many low-income countries (LICs) are found. In the 1980s, budget cuts led to a reduction in Technical Vocational Education and Training (TVET) in Africa, which has still not recovered. In 2012, only 6% of the total secondary enrolments were in TVET (African American Institute, 2015). According to the Trends in International Mathematics and Science (TIMS) study and the UNESCO Global Monitoring Reports, the performance of African students in mathematics and science is persistently lower than international averages (Hooker, 2017). Hence, the quality of STEM education is poor in Africa.

STEM education is fairly globalised: Commonwealth countries follow trends in the United Kingdom while European and Asian countries tend to follow developments in the United States (Williams, 2011). However, the majority of technologies which developing countries need to reduce poverty, add value to natural resources and improve the efficiency of domestic industries, have already been invented and are widely used in high-income countries. The issue is that these technologies are not very prevalent in many developing countries. Consequently, the priority for STEM education requires developing engineering, technical and vocational skills rather than conducting state-of-the-art research and development (Watkins & Ehst, 2008). For example, tertiary science and technology education can accelerate the development of a knowledge-based economy in developing countries. In addition, it is critical for research to focus on making STEM relevant to local problems and development issues.

The literature mentions the following justifications for STEM education:

- STEM education is proposed as a response to depressed economies (Williams, 2011). There is a correlation between the promotion of technology education and economic depressions in the 1890s, 1930s and 1980s (Williams, 2011);
- According to Development Visions, a significant policy document, development in low or lower middle-income countries in sub-Saharan Africa tends to follow similar patterns (Tikly et al., 2018). These countries pursue industrialisation and economic diversification so that their economies can grow. Manufacturing and services industries which are critical for industrialisation require knowledge of mathematics and science. Mass secondary education is perceived as necessary for developing human capital to facilitate industrial development and modernisation of the economy. Hence, mathematics and science were promoted in Tanzania and Senegal (Tikly et al., 2018). The Vision 2020 strategy in Nigeria has ambitious economic development targets which require a skilled workforce and STEM education can contribute to this especially in the manufacturing sector (Ohize, 2017);
- STEM can improve competitiveness in the global economy (Iksan, 2009). There is a desire to keep pace with high-technology sectors in Asian countries (Williams, 2011). Greater emphasis on TVET is needed to enhance Africa's global competitiveness (African American Institute, 2015);
- Curbing unemployment, which arises because workers do not have the skills required by employers: for example, Latin America has an unemployment rate of 13% but half the employers in a survey reported that they could not find qualified candidates. Similarly, skills taught in the Middle East and North Africa do not match with the requirements of employers (Burnett & Jayaram, 2012);
- The changing job requirements which arise from developments in information and communication technology (ICT). For example, it is envisaged that jobs for routine

production workers will disappear as a result of the potential for ICT to perform routine tasks (Voogt & Roblin, 2012); and

- Training for informal sector workers through apprenticeships and other programmes: for example, in Senegal 10,000 young people received TVET training for the motor repair sector (Burnett & Jayaram, 2012: 18).

Key Trends in STEM education

This section discusses some of the key trends in STEM education mentioned in the literature:

Integrated STEM education

In 2010 scholars in developed countries proposed that the teaching of science, technology, engineering and mathematics at secondary education level should be integrated into one subject under the guise of STEM (Hooker, 2017). Teachers of STEM would be able to teach any of the subjects (Hooker, 2017). The main motivation for an integrated STEM discipline at secondary school level was a response to vocational needs and economic aspirations (Williams, 2011). However, this approach has been criticised for lacking clarity and undermining technology training. Moreover, the individual components of STEM are based on different epistemological assumptions, and these differences should be respected (Ostler, 2012; Williams, 2011).

21st-century competence

Globalisation and the rapid development of ICT are transforming society. Consequently, STEM is necessary to meet demands for 21st-century workplaces (Hooker, 2017). There are a number of frameworks for 21st-century competences such as the assessment and teaching of 21st-century skills developed by companies such as Cisco, Intel and Microsoft, the partnership for 21st-century skills developed by the Centre of K-12 education in the United States, 21st-century skills and competences for the new millennium learners developed by the Organisation for Economic Cooperation and Development and the ICT competency framework for teachers developed by UNESCO (Voogt & Roblin, 2012:21). A review of these and several other frameworks for 21st-century competence found that all refer to information literacy, technological literacy and ICT literacy (Voogt & Roblin, 2012). Information literacy refers to the capacity to access information in an efficient and effective manner, as well as the ability to critically evaluate information. ICT literacy refers to more than technical skills and includes the use of digital technology, communications tools or networks to operate in a knowledge society. Technological literacy refers to the ability to use, understand and evaluate technology as well as applying it to develop solutions for particular problems (Voogt & Roblin, 2012). Thus, in the knowledge society students will have to understand and evaluate the different technologies which they utilise.

A new set of skills, generally possessing the following qualities, are required for the 21st-century according to Voogt & Roblin (2012: 300):

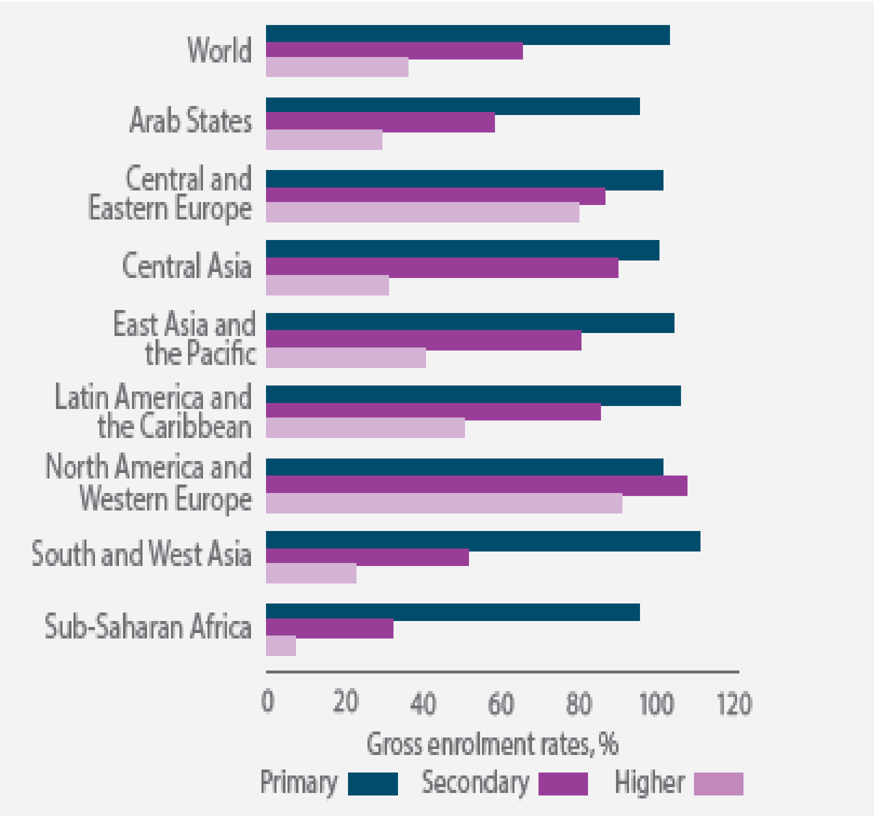
- Transversal – i.e. they are not directly linked to a specific field but are relevant across many fields;
- Multidimensional – i.e. they include knowledge, skills and attitudes; and
- Association with higher order skills and behaviours – i.e. enabling people to cope with complex problems and unpredictable situations.

It is expected that schools will be required to make curricular changes in order to prepare students for the knowledge society, and in addition it may be necessary to redefine what should be included in the core secondary school curriculum (Voogt & Roblin, 2012).

3. STEM and gender differences

Women lag behind men with regard to access to secondary and tertiary education in developed and developing regions of the world (UNESCO, 2017). Figure 1 reveals that the gender gaps are significant in sub-Saharan Africa, the Arab states, and south and west Asia. In sub-Saharan Africa most countries have achieved gender parity with regard to completion of primary and lower secondary education (Masanja, 2010). However, there is still a gender gap in terms of access to upper secondary and tertiary education (Masanja, 2010).

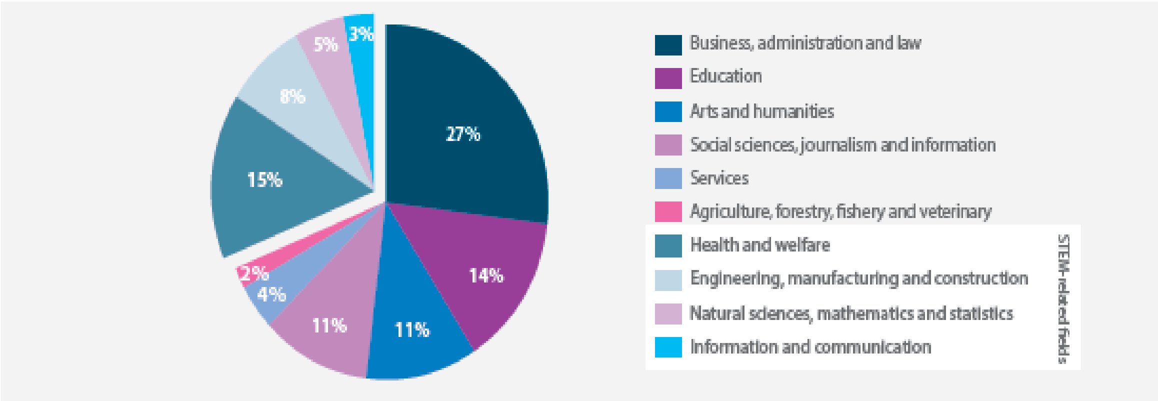
Figure 1: Girls Enrolment Ratios in primary, secondary and higher education, 2014 (200 countries and dependant territories)



Source: UNESCO, 2017:18

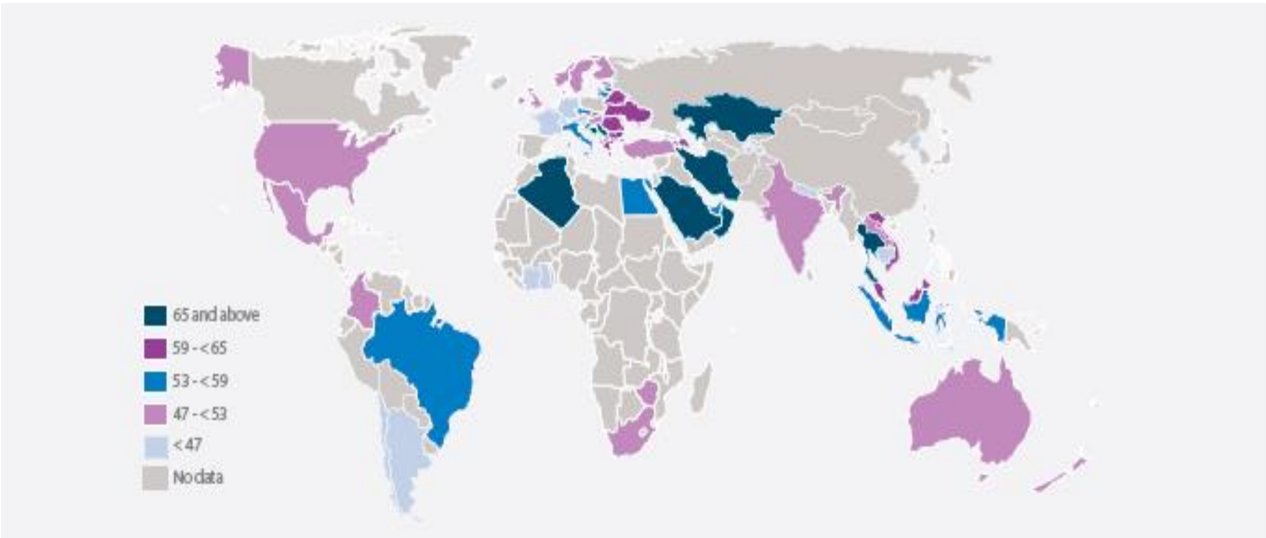
The literature on STEM and girls focuses on statistics which reflect that females have less access to STEM education, descriptions of programmes which aim to broaden access to higher education for girls, and explanations of the factors that inhibit interest in STEM among girls. Figure 2 reveals that across the world only 30% of female students pursue STEM related high education studies. However, Figure 3 reveals that there is no data on the composition of females in STEM related higher education courses in many of the poorest countries in the world.

Figure 2: Distribution of Female Students Enrolled in Higher Education - World Average (110 countries and dependant territories)



Source: UNESCO, 2017:20

Figure 3: Percentage of Female Students Enrolled in Science, Mathematics and Statistics at Higher Education Level (82 countries)



Source: UNESCO, 2017:21

The literature does not discuss the benefits of providing STEM education for girls. UNESCO adopts a rights-based perspective and argues that it is a human right to provide girls with equal access to STEM education as it enables them to pursue the career of their choice (UNESCO, 2017). Moreover, women have already made valuable contributions to this field and the catalytic role of STEM is enhanced by their participation (UNESCO, 2017). UNESCO has responded to issues relating to gender gaps in education by mainstreaming gender across all programmes and activities. The goal is to fully integrate gender equality considerations into all programmes. In addition, there are gender specific interventions which aim to address specific inequalities (IOS, 2017). An evaluation of UNESCO interventions aimed at improving access to education for girls broadly claims that STEM education for girls contributes towards the Millennium Development

Goals and the strategic development goals but does not provide further detail on how this can be accomplished (IOS, 2017).

Case studies

Yuwa soccer programme, India

The Yuwa programme offers soccer training to girls from low income families in rural India. The broader aim of the programme is to increase school attendance, enhance general skills development and empower girls to break social constraints (Burnett, 2013). The Kicking It New School is a new component of the Yuwa programme in Jharkund, India. It provides supplementary education through technology using e-readers. Peer educators aged between 12 and 14 years old act as “guides on the side” and help other children to use e-learning resources. The aim is to raise participation in maths and science levels by two standards. Through the use of e-readers and eventually tablet computers the girls will become familiar with technology and this is anticipated to stimulate their interest in STEM. The cost of the tablet programme is USD 13 per participant, and the e-reader lasts up to three years. Thus far, the programme has been evaluated in terms of school and soccer practice attendance which has been high for the participants (Burnett, 2013).

Science Technology and Mathematics clinics, Ghana

The Science, Technology and Mathematics clinics were set up to help a selection of promising female secondary school students participate in a specialised STEM study programme. According to the Ministry of Women’s and Children’s Affairs, 40,908 girls participated in the STEM clinics between 1986 and 2010. In addition, female participation in science and mathematics at tertiary institutions rose from 12% to 25% (Bermingham & Engmann, 2012).

4. Benefits of STEM education

The following benefits of STEM education are discussed in the literature.

Improving professional development

Most of the literature on STEM education mentions training for teachers which helps them to improve their teaching with the aid of ICT, or to enhance their teaching capacity in STEM subjects (Hooker, 2017). Case study evidence suggests that there are promising models for teaching and learning, and professional teacher learning through technology.

Africa

The Digital Education Enhancement Project (DEEP) in Egypt and South Africa pilots show that the limited range of new technologies adopted in professional development. Participatory research played a significant role in transforming opportunities for teacher education, and had a positive impact on universal basic education in terms of attendance, motivation, quality of learning, literacy, numeracy and science (Hooker, 2017). In addition, ICT-enabled teaching can result in more positive attitudes among students especially if students enjoy working with devices: “There is a growing emphasis on the use of technology to support deeper learning approaches for engaging students in the 21st century of critical thinking, problem solving, collaboration and self-directed learning" (Hooker, 2017:11).

Meeting workplace demands

Mathematics and science are necessary to meet the demands of the modern workplace. Thus, an emphasis on STEM education could resolve unemployment problems (Hooker, 2017). An investment in STEM is needed for a transformative shift in Africa. The International Monetary Fund (IMF) predicts very high growth rates in Africa, similar to Asia. There is a shortfall of five million scientists and engineers, while more than 80% of students are enrolled in social sciences and humanities courses (Hooker, 2017:14). However, an investment in STEM education, such as TVET, does not necessarily lead to employment because it is a supply-side initiative (African American Institute, 2015). Below is a review of the literature on the skills needed for employability in two regions where there are low -income countries:

Africa

The skills gaps in Africa relate to numeracy, critical thinking communication, leadership, decision-making and technical capacity. Non-cognitive skills (e.g. communication, leadership and decision-making) are becoming increasingly important as economies transform. Burnett & Jayaram (2012) conducted a survey of 83 employers in Benin, Burkina Faso, Kenya, Senegal and Uganda to assess the skills needs of employers. Employers in Benin prefer employees to have some university education and prioritise non-cognitive or social skills (Burnett & Jayaram, 2012). Across all countries, the public sector is the main employer for secondary school leavers. Small and medium enterprises prioritise cognitive over non-cognitive skills, while larger firms require both. TVET is needed in finance and construction. The Association for the Development of Education in Africa found that communication skills are crucial and social skills are especially valuable for young recruits (Burnett & Jayaram, 2012).

The curricula for African countries in the survey emphasised cognitive skills (literacy, numeracy and scientific literacy) and some non-cognitive skills such as reliability and communication as well as specific technical skills (Burnett & Jayaram, 2012). Vocational education is proposed as an important reform for the education system (Burnett & Jayaram, 2012). TVET curricula should be responsive to market demands. For example, in Ghana the TVET curricula has compulsory English, mathematics, social science and integrated science courses. In Mali, Senegal and Togo apprenticeships are included in TVET courses. Some secondary schools in Kenya have been vocationalised to include agriculture, business, computing, home science and industrial education. Despite these initiatives, direct links between schools and employers are lacking (Burnett & Jayaram, 2012). One of the main challenges of aligning education with the needs of employers is that the majority of women in Africa are employed in the informal sector.

Asia

A survey of employers in India, Pakistan and Bangladesh found that 56% of employers prioritised non-cognitive skills. This study uncovered regional differences. For example, a large city like Delhi has a better educated population compared with other cities, and many of its residents have strong interpersonal skills. Consequently, the skill requirements in Delhi reflect a mix of advanced cognitive and non-cognitive skills. In contrast, other cities with a less educated population, for example Lahore and Bhopal, require basic skills as well as non-cognitive skills such as honesty and a strong work ethic (Burnett & Jayaram, 2012). However, the skills requirements in 11 high-growth sectors in India reflected a greater need for skills relating to STEM, see Table 1.

Table 1: Skills needs in a sample of high growth sectors in India

Sector	Skill gaps
Automobiles	Three subsectors of the automobile industry experience very different skill issues: • Service: The biggest skill gaps are the inability to understand how a small task such as tightening a bolt fits into the bigger picture; inadequate knowledge of automobile machinery trade knowledge, or poor application of available knowledge; absenteeism; and the lack of skill standardization across employees trained in the same functions at different training institutes. • Manufacturing: No particular skill gaps. Mainly technical skills are required and available. • Mechanics: Even more technical skills are required than in manufacturing and these are seriously lacking, especially an understanding of the functions of and differences between automobile parts, a tendency to rely on judgment rather than on instructions and manuals, and so forth.
Information technology	Major skill gaps can be divided into two types: • Functional skills: Weak analytical ability, lack of attention to detail, lack of understanding of information security and privacy issues. • Soft skills: Weak communications, multitasking, perseverance, problem solving.
Finance (especially that which is outsourced to India)	Non-cognitive skills such as communication, perseverance, emotional intelligence, aptitude for repetitive work, knowledge of the industry and of such things as asset classes, basic finance.
Tourism	Inadequate knowledge of geography, communications, and safety measures. Many employers even cite a gap for basic skills such as reading, writing, and math.
Construction and real estate	Inadequate knowledge of construction and of basic machine operations, and inability to understand instructions. Problems attributed to the excessively theoretical vocational training in Indian institutions with insufficient practical work.
Textiles	For machine operators, technical skills gaps, especially lack of understanding of machines plus non-cognitive inability to multitask. For supervisors, both the same technical skills gaps and also management skills.

Source: Burnett & Jayaram, 2012: 16

A survey in Cambodia, Thailand and Vietnam found that employers were generally dissatisfied with the skill level of secondary school leavers. Moreover, neither general nor vocational secondary education was providing school leavers with the skills that they required for the workplace, including basic subject knowledge, analytical skills, management skills, technical skills, teamwork, foreign languages, computer and ICT skills, problem solving skills and interpersonal skills (Burnett & Jayaram, 2012: 16). In Cambodia the survey found that only 13% of employers believe that graduates have all or most of the skills required for the labour market (Burnett & Jayaram, 2012). They were also concerned about the attitude towards work among unskilled workers and the level of problem-solving and analytical skills among skilled workers and professionals, respectively. Burnett & Jayaram (2012) note that similar findings emerged from other studies. Employers in Vietnam prioritised information skills including the computer processing of information, resource skills such as time management and interpersonal skills like teamwork or negotiation (Burnett & Jayaram, 2012).

Vocational education is less stigmatised in South-East Asia compared with either South Asia or Africa (Burnett & Jayaram, 2012). Afghanistan, Nepal and Pakistan are moving towards a skills development orientation. A skills qualification framework such as the National Qualifications Framework for Vocational Education in India is necessary to allow students in vocational education to undertake further studies. Despite these reforms, students in Asian countries still do not fully meet the requirements and needs of employers. The shortfall is attributed to ineffective teaching (Burnett & Jayaram, 2012).

STEM education for sustainable work

The concept of sustainable work is proposed to challenge the perspective that work is mainly for financial gain (Likly et al., 2018). It recognises that there are many forms of unpaid or informal work which contribute to society. According to Likly et al. (2018:18) STEM education can contribute to sustainable work as follows:

- The supply of skilled workers for social professions can be boosted through STEM education. For example, in sub-Saharan Africa there is a need for 5.7 million teachers and 3.8 million health workers;
- Given the scale of the informal sectors in many LICs, secondary education should provide the skills for self-employment and entrepreneurship. Many artisan and trade occupations require STEM knowledge although there is more emphasis on technology. Hence, TVET is essential and it may be necessary to offer it earlier at secondary education level.
- Rapid urbanisation and internet expansion creates job opportunities in the ICT sector, therefore it is critical to have training in ICT at secondary school level;
- Lower secondary education should provide adequate STEM knowledge of hygiene and health to enhance living standards. For example, knowledge on disease and infection are included in the biology curriculum at lower secondary level in Tanzania;
- Vocational subjects such as agriculture and domestic science include STEM content which may be useful for rural students who undertake cattle hoarding, small-holder agriculture or fishing; and
- Voluntary and creative work requires basic STEM knowledge such as ICT skills for audio visual editing or chemistry knowledge for mixing dyes.

Innovative models of secondary education

Bermingham & Engmann (2012) discuss the impact of several innovative models for improving STEM in secondary education:

- Ghana developed 108 communal Science Resource Centres to improve STEM education. A significant improvement in the percentage of candidates who passed the West Africa School Certificate Examination between 2005 and 2010 was found. The performance in mathematics improved very significantly for girls and boys. The cost of the programme was GBP 6 million. There were challenges in terms of coordination among schools within the programme, and additional funding was required to sustain the programme (Bermingham & Engmann, 2012).

- The Emusoi Centre in Tanzania provides girls with academic and vocational secondary school education. The programme targets young woman from poor families. Scholarships and remedial tuition is provided to participants. The programme has supported over 1,000 students since its inception in 2000. The participants have pursued careers such as social work, law, accountancy, administration, IT, teaching, community development, journalism, nursing, laboratory technology and jobs in the tourism sector. The cost is estimated at USD 1,000 per student (Bermingham & Engmann, 2012).
- In Cambodia IT courses are provided to disadvantaged young people who are enrolled in vocational training programmes. A pilot e-learning project was launched to help students to learn using online materials to complement face-to-face classroom activities. Thus far, there has been no formal assessment of the programme in terms of its impact on students' performance (Bermingham & Engmann, 2012).

Domestic development

Sohoni (2012) is sceptical about the development dividend arising from research and development at the Indian Institute of Technology (IIT) for the following reasons:

- The focus was on international research and development issues that would result in publications in international peer reviewed journals;
- There was little interest in studying or finding solutions for local development problems;
- There is little support for research from the private sector, and
- Most graduates go into the private sector to work, and there is shortage of engineers in the public sector which subsequently has a negative impact on public infrastructure development.

5. STEM education in Rwanda

In order to provide a focus on low income countries this section describes the impact of two STEM education projects in Rwanda:

Kigali Institute of Science, Technology and Management (KIST)

KIST was founded in 1997 to help Rwanda recover from the genocide which resulted in the death or departure of most skilled professionals. The academic programmes are demand driven so that they produce skilled technicians at different levels to meet the needs of the labour market (Lwakabamba & Lujara, 2003). There is a continuing education programme which provides short courses so that technicians and artisans can update their knowledge and become more efficient. There is a production department which oversees several income generating activities. There is an emphasis on locally produced technology which has resulted in the building of bio-gas and bio-latrine plants for schools, prisons and hospitals (Lwakabamba & Lujara, 2003). Cooking stoves and efficient breadmaking ovens have been developed for local communities. A cottage industry unit has been established to train disadvantaged people and stimulate entrepreneurship.

SIDA Collaboration Programme in Rwanda

SIDA funded a collaboration project between the University of Rwanda (UR) and 12 Swedish universities. The programme began in 2002 and is in its third phase which runs from 2013 to 2018 (Tvedten, Byabagambi, Lindström, & Tedre, 2018). The programme provides training for graduate students, assistance with curriculum development, joint research projects and institutional capacity building. The budget for phase 3 is SEK 334 million. The overarching objective of the project is to increase production and use of scientific knowledge and thus contribute to the development of Rwanda. Moreover, it is envisaged that the research will contribute to better policy-making and improved products or services produced by the private sector and civil society organisations in Rwanda (Tvedten et al., 2018). Although Rwanda has experienced impressive economic growth recently, the majority of the population is still engaged in subsistence farming and the government recognises that structural transformation is necessary. An evaluation of the programme ascertained the following findings (Tvedten et al., 2018):

- The majority of PhD graduates are in Peace, Conflict and Development studies. The best record in terms of completion is in ICT research and Mathematics. Roughly half (47%) of the PhD students finish in five years, which is a relatively low dropout rate compared with other programmes between Swedish and African universities.
- The Theory of Change specifies that research capacity can be improved by providing an enabling environment for research. The programme supports a research directorate, Management Information System, and institutional advancement and research infrastructure. However, despite these administrative improvements the environment is still not conducive to research due to procurement problems, lack of incentives arising from the performance appraisal system (which does not reward staff for research output), and heavy teaching and administrative duties - which permit little time for research.
- Swedish universities claim that it leads to valuable research findings and secures steady access to Rwandan PhD students. The main contribution of the Swedish partners was in terms of theory, methodology and academic writing, as these were areas where students were generally weak.
- There is still a gender imbalance at UR as men occupy most high-level positions.
- Overall, Rwandan and Swedish counterparts regarded the programme as a success in spite of its shortcomings.

6. References

African American Institute. (2015). State of Education in Africa Report 2015. Retrieved from www.aaionline.org/wp-content/uploads/2015/09/AAI-SOE-report-2015-final.pdf

Bermingham, D., & Engmann, M. (2012). *Innovative models for employability in Africa and Asia*. Washington, DC: Results for Development Institute. Retrieved from https://www.r4d.org/.../InnovativeSecondaryEducationSkillsEnhancement-PhaseI-Syn..

Burnett, N. (2013). *Pathways to employability: lessons and case studies for closing the youth skills*. Washington, DC: Results for Development Institute. Retrieved from http://www.aaionline.org/wp-content/uploads/2014/09/R4D-Pathways-to-Employability.pdf

Burnett, N., & Jayaram, S. (2012). *Innovative Secondary Education for Skills Enhancement: Skills for Employability in Africa and Asia*. Washington, DC: Results for Development Institute. Retrieved from https://www.r4d.org/.../InnovativeSecondaryEducationSkillsEnhancement-PhaseI-Syn..

Hooker, M. (2017). *A Study on the Implementation of the Strengthening Innovation and Practice in Secondary Education Initiative for the preparation of Science, Technology, English and Mathematics (STEM) Teachers in Kenya to integrate Information and Communication Technology (ICT) in Teaching and Learning* (PhD Thesis). Queen's University Belfast.

Iksan, Z. (2009). Promoting cooperative learning in science and mathematics education: A Malaysian perspective. *Colección Digital Eudoxus*, (7).

IOS. (2017). *Evaluation of UNESCO's Programme Interventions on Girls' and Women's Education*. Internal Oversioght Service. Retrieved from www.unesco.org/.../PI_165_Rev_Evaluation_of_UNESCOs_Programme_Intervention

Likly, L., Joubert, M., Barrett, A.M., Bainton, D., Cameron, L., & Doyle, H. (2018) Supporting Secondary School STEM Education for Sustainable Education in Africa. Working Paper 05/2018. University of Bristol. Retrieved from http://www.bristol.ac.uk/media-library/sites/education/documents/Supporting%20Secondary%20School%20STEM%20Education%20for%20Sustainabale%20Development%20in%20Africa.pdf

Lwakabamba, S., & Lujara, N. K. (2003). Effective Engineering Training: the case of Kigali Institute of Science, Technology and Management. *Global Journal of Engineering Education*, *7*(1), 71–76.

Masanja, V. G. (2010). *Increasing Women;s Participation in Scince, Mathematics Ad Technology Eudcation and Employment in Africa* (Exoert group meeting). Paris: UNESCO. Retrieved from www.un.org/womenwatch/daw/egm/gst_2010/Masanja-EP.8-EGM-ST.pdf

Ohize, E. J. (2017). Repositioning Science, Technology, Engineering and Mathematics Education for Economic Recovery in Nigeria. Conference Proceedings. "Reposition Science, Technology, Engineering & Mathematics (STEM) Education for Economic Recovery in Nigeria." Kontagora, Niger State. Retrieve from www.sciencesfcekg.sch.ng/downloads/ConferenceProceedings_11th_2017.pdf

Ostler, E. (2012). 21st century STEM education: A tactical model for long-range success. *International Journal of Applied Science and Technology*, *2*(1).

Sohoni, M. (2012). Engineering teaching and research in IITs and its impact on India. *Current Science*, *102*(11), 1510–1515.

Tvedten, I., Byabagambi, A., Lindström, J., & Tedre, M. (2018). Evaluation of the Sida supported research capacity and higher education development programme in Rwanda, 2013-2017. *Sida Decentralised Evaluation*. Retrieved from https://www.sida.se/contentassets/.../de2018_3_62126en.pdf

UNESCO. (2017). *Cracking the code: Girls' and women's education in science, technology, engineering and mathematics (STEM)*. UNESCO. Retrieved from unesdoc.unesco.org/images/0025/002534/253479e.pdf

Voogt, J., & Roblin, N. P. (2012). A comparative analysis of international frameworks for 21st century competences: Implications for national curriculum policies. *Journal of Curriculum Studies*, *44*(3), 299–321.

Watkins, A., & Ehst, M. (2008). *Science, Technology, and Innovation: Capacity Building for Sustainable and Poverty Reduction*. The World Bank.

Williams, J. (2011). STEM education: Proceed with caution. *Design and Technology Education: An International Journal*, *16*(1).

Acknowledgements

We thank the following experts who voluntarily provided suggestions for relevant literature or other advice to the author to support the preparation of this report. The content of the report does not necessarily reflect the opinions of any of the experts consulted.

- Michael Latham, Education Development Trust.
- Róisin Plunkett, Education Development Trust.

Key websites

Closing the STEM Gap: https://news.microsoft.com/uploads/2018/03/MSFT-STEM_Infographic.pdf

Bridging the Gender Gap: https://www.theguardian.com/science/head-quarters/2018/mar/08/bridging-the-gender-gap-why-do-so-few-girls-study-stem-subjects

Girls in STEM: https://www.theguardian.com/science/head-quarters/2018/mar/08/bridging-the-gender-gap-why-do-so-few-girls-study-stem-subjects

Research on SETM: https://www.aauw.org/aauw_check/pdf_download/show_pdf.php?file=why-so-few-research

Closing the Stem Gap: https://thejournal.com/articles/2018/03/13/closing-the-stem-gap.aspx

Suggested citation

Ismail, Z. (2018). *Benefits of STEM Education.* K4D Helpdesk Report. Birmingham, UK: International Development Department.

About this report

This report is based on five days of desk-based research. The K4D research helpdesk provides rapid syntheses of a selection of recent relevant literature and international expert thinking in response to specific questions relating to international development. For any enquiries, contact helpdesk@k4d.info.

K4D services are provided by a consortium of leading organisations working in international development, led by the Institute of Development Studies (IDS), with Education Development Trust, Itad, University of Leeds Nuffield Centre for International Health and Development, Liverpool School of Tropical Medicine (LSTM), University of Birmingham International Development Department (IDD) and the University of Manchester Humanitarian and Conflict Response Institute (HCRI).

UKaid
from the British people