Review Article

Artificial intelligence program implementation in STEM education: Cases of Ethiopia STEM Center

Yohannes Degefu Shumiye [1]* iD

[1] Serkalem Fikadu, Addis Ababa, ETHIOPIA
*Corresponding Author: yohanesdegfu@gmail.com

ARTICLE INFO	ABSTRACT
	This literature review to examine the status of artificial intelligence (AI) technology in Ethiopian STEM (science, technology, engineering, and mathematics) schools and the possibility of implementing AI programs in the future. Many developed and developing countries are using AI to help grow and improve their economies. They are using AI to leverage their technology and services. The primary use of technology AI is to make teenagers with mathematics and science skills more creative in their learning. This literature review article aims to provide alternative directions on how to implement AI programs in Ethiopian STEM schools, with an emphasis on learning from developed countries and sharing best practices. Primary and secondary data will be used: Secondary data will be analyzed on theory-based evidence, and primary data will be analyzed based on structured questionnaires. In order to achieve this goal; select journals, research and other related websites will be reviewed. Considering the findings of this review indicate that in STEM schools, there are many teen-agers with specific interests and abilities in mathematics and coding. This knowledge is mainly needed for AI, and purpose of this literature review is to encourage reflection on advantages of basic AI concepts for youths as it can help to engage talented students in learning. This paper thoroughly analyzes relevant research and interview data to highlight key insights, current status, challenges, and future directions for AI implementation in Ethiopian STEM schools.

INTRODUCTION

General

Artificial intelligence (AI) has been defined in many different ways over the past few decades. However, according to McCarthy (2007),

> AI is the scientific and engineering of creating intelligent machines, particularly intelligent computer programs, in comparison to the task of understanding human intelligence through the use of computers.

The Google definition is the most helpful for the purposes of this literature review. According to Google, AI is a collection of technologies that allow computers to perform various advanced functions. According to Stanford University (2022),

> AI is the driving force behind innovation in contemporary computing, providing value to individuals and businesses

and

AI is a rapidly changing technology that is transforming the world,

while "intelligence" can be defined, as follows:

> the capacity to learn and execute appropriate techniques to resolve problems.

These definitions make it clear that this sector is crucial for the development of nations like Ethiopia in addition to helping to solve problems.

Opportunities of Artificial Intelligence

When studies discuss the growth and advantages of this sector for developing countries, the studies suggest that on AI by studying the experience of developing countries and bringing the advantage in this field to the study would be a good option for developing countries to focus on this sector in order to increase their productivity and achieve rapid growth (Kesherti, 2020; Su & Zhong, 2022). As referred to in prior studies on AI opportunities discussing review (Girmay, 2019; Gwagwa et al., 2020; Tamirat, 2021). These studies have laid out the benefits and challenges of AI in a wide range and she

also stated that it is good if it is supported by policy. To analyze and study gaps that have not been widely considered, I will use her research results as a reference.

Based on the experience of many developed countries, studies show that economic growth and the use of AI are key to the development of developing countries like Ethiopia (Girmay, 2019). Research in this area supports this theory, indicating that utilizing AI technology is essential for boosting economic growth in developing nations such as Ethiopia. However, articles in these fields state that while technology is useful, there is a lack of skills in Africa due to a lack of political support to develop the sector (Nayebare, 2019). According to his research, countries including Ethiopia are facing these problems and I agree with him. They show in their research that they are at a low level in the adoption of digital and AI, and they also do not support the development of the sector through policy (Gwagwa et al., 2020).

STEM Education for Artificial Intelligence

According to Mintesnot (2020), who studied STEM centers in Ethiopia, students attending high schools with a STEM focus participate well in science and mathematics subjects, enjoy solving mathematical problems and using technology, which leads to good results in engineering in the future (Weintrop et al., 2016). Explaining the positive effects of STEM centers on students. He was clearly wrote the idea that I support. Given the abundance of opportunities for students to solve problems, implementing STEM education is a promising strategy for educators to foster creative problem-solvers. For the benefit of this industry and to advance my research, it would be advantageous to start providing basic AI technology to STEM schools.

In another research paper by Yang (2022) mentioned under the title of "Artificial intelligence education for young children: Why, what, and how in curriculum design and implementation", the research on teenagers in developed countries when he says "AI for kids" when he explained why they have the skills to embrace the digital world so quickly to use those AI tools mentioned above? To function, AI technology needs the following abilities: Using a large amount of data as input, AI algorithms can be continuously trained to spot patterns, make predictions, and suggest actions. In programming, STEM students who are good and talented in mathematics are supported, they can make important innovations in AI, because basic mathematical skills are key in this field, as many studies have shown. This review is supported by this literature mentioned that mathematics education is an important learning sources for STEM schools (Sithole et al., 2017). The research on STEM schools conducted by Suh and Han (2019) stated that STEM schools have found significant benefits of using mathematical modeling experience. Research concludes that if they excel in mathematics, they are satisfactory for university and reinforced this research by providing an opportunity to engage in complex problem-solving (Hobbs, 2011). If the field involves young people from the start, they can work on the innovative results of AI technology. I agree with some features as options. This includes, for example, laboratory work in the fields of natural sciences, mathematics, information communication technology (ICT) and electronics, encouraging students to work on projects in various fields, as well as offering summer training programs for programs (for talented students) and a math-camp program.

Also clearly noted opportunities STEM using ICT in sub-Saharan Africa (SSA) studies led to the conclusion that "every African country should have a national ICT policy with a clear vision and a defined strategy", which creates an enabling system to promote ICT research, development and innovation in relation to education of students in AI before entering university (Barakabitze et al., 2019). This idea is supported by Guerreiro-Santalla et al. (2020) who highlighted the potential of AI in early childhood. education that conducted a design study on AI. Similarly, a study by Yang (2022) described how to engage children in a meaningful experience that enables them to learn these fundamental AI concepts in AI education for youth: The why, what and how of curriculum design and implementation. The majority of the research papers on the STEM schools suggest that talented young students can perform well if they gain knowledge of AI before starting their university education. However, this review of the literature agrees with their work and points out a significant gap in their implementation.

Ethiopian STEM Schools Status & Policies on Artificial Intelligence Implementation

According to the description of the STEM institution's mission statement (STEM power and STEM synergy) most STEM schools in Ethiopia are located nearby or on campus as university property. Such institutions maintain strong university-community ties, provide academic oversight and achieve sustainability. Larger STEM centers are environmentally friendly buildings designed for laboratories, offices, storage facilities and auditoriums for science fairs and community meetings. 34 of them received help in their work, 22 of them are located in Ethiopia and the rest in SSA countries. The areas of technology that the university supports and trains in detail are virtual computing and electronics (both digital and analog as well as microcomputers), 3D printing, and the development of programs in earth and water engineering, chemical engineering and biomechanics. These listed fields may have better results if AI supports them. Although many studies have widely documented the potential of STEM centers (Tamirat, 2021), this study supports the lack of implementation strategies in STEM centers, but also does not focus on AI. There is a flaw in the scientist's argument that it will be useful if the strategic goals of politics are supported by the implementation of AI programs.

National STEM Policies in Ethiopia

The Ethiopian education system consists of two basic education periods; two years of general secondary education; after that, either a university preparatory program or technical vocational education. Mathematics is offered separately in elementary and middle school. Students then study STEM and related subjects, including physics, mathematics, and engineering, life science and health, education, business, and finance, and other related fields.

In addition, the Ethiopian government has recently paid attention to science, technology, engineering and mathematics education. One example of this is the goal of a 70:30 enrollment mix, where 70% of enrolled students should be in science and technology and 30% in social sciences. In addition, the government established the Ethiopian Center for Strengthening Mathematics and Science Education under the Federal Minister of Education, which is responsible for science and mathematics education across the sector. These initiatives are useful in AI if students have good mathematics skills, but the policy does not mention AI.

However, the findings of the JICA study in Ethiopia demonstrate that, as stated in the title (strategic policy for national science, technology, and mathematics education), a study of developed nations' experiences supports my research by demonstrating that China's ability to compete economically with the United States in the 21st century and achieve the level it has now was largely due to its emphasis on STEM schools support. Since the United States has been in the 21st century and has reached the level it is now, the focus must be on supporting the STEM Institute. According to Tikly et al. (2018), African STEM education policy African teaching describes the research. Supporting politicians and giving people the skills they need for politics is also crucial:

> The role of STEM education in today's global policy debate, including the skills needed for sustainable economic, social and environmental development and combating youth unemployment.

Gwagwa (2019) shows that SSA countries are increasingly engaged in AI, but also have little government support. The adoption of AI technology is increasingly common on the African continent, but political action measures on AI based policy is still in its infancy. However, the experience of some countries shows, according to research, that if the implementation of AI program is supported by policy, it is possible to achieve changes in a short time. As he mentions earlier, only one study so far has examined the benefits of using new technology and summer camps at STEM centers. However, there are studies showing that this technique can be used as an alternative (Mintesnot, 2020).

Kesherti (2020) said in his research, by supporting the police, it is possible to reduce the challenges associated with the introduction of AI this negative effect can face. While he explained that the use of technology is beneficial to developing countries, he also partially backed up his words about reducing challenges but did not mention its implementation. Ethiopia can achieve good creative results if it starts to train and apply this technology from the ground up with STEM students doing a core program in AI. However, this is a country-specific investigation that confirms the existence of this problem. A report of Ethiopia technology policy shows that it does not receive much attention, but it shows the experience of some countries when it supports the policy and works with teenagers (UNCTAD, 2020).

Teachers Skill & Infrastructures

According to research conducted in ILO and JIZ reports, the use of digital technology in Ethiopian schools is at an early stage, mainly due to the limited development of ICT and the lack of trained human resources (Yigezu, 2021). The problems mentioned above are defining moments in the development of AI technology. The results showed that due to the limitations of ICT infrastructures and qualified human capital, there is a premature stage of implementation. Ethiopia has made ambitious attempts to connect its education system with automation and the Internet of things. In this research results, presented under the headings "Digitalization of teaching and education in Ethiopia", the explanation is, as follows: Critical gaps in the use of digital technology are the following: developing the capacity of digital and pedagogical skills of in-service teachers through continuous professional development; reforming teacher education to increase the use of digital technology. According to a survey of STEM school teachers, the general shortage of qualified teachers in SSA is most evident in STEM subjects. It is clear that the problem is not only ICT infrastructure, but also the government and its lack of policy and support. This literature review paper will investigate the implementation of this problem by examining the reasons why technology did not bring about a change in practice.

Objectives

STEM schools have become essential in the development of youth's knowledge and skills. On the basis of this, according to the study, countries in SSA, including Ethiopia, have a large number of young people, so STEM centers play an important role in AI innovation. Therefore, because in schools they teach teenagers science and mathematics by explaining and supporting them in the laboratory; research shows that the field of AI technology must be enriched with programs based on mathematical and coding skills.

The objectives of this literature review are to provide a possible directions to the current state of institutions in the field of artificial intelligence technology by analyzing and examining evidence from STEM schools.

METHODOLOGY

A systematic literature review approach was used to describe current trends, challenges and possible future directions for AI program implementation in STEM schools in Ethiopia. For this review were selected from secondary sources and a qualitative methodology involving structured interviews with school principals. A transparent way of answering research questions is useful for summarizing the latest knowledge on a given topic through a systematic review. This review paper looked at how artificial intelligence was being used in Ethiopian STEM schools. The literature revealed that STEM school supporters STEM Power and STEM Synergy, as well as school administrators, were actively involved in discussions about implementing AI programs.

Previews Studies

Conduct an extensive literature review to identify theories and previous research activities that relate STEM centers to AI. Gather basic information of secondary data from academic

journals and online sources. Surveys covered implementation of AI programs and their relevance to this sector.

Method of Data Collection

This study focused primarily on program implementation through a systematic review of the literature, with a particular focus on AI in STEM schools. Topics like the status of schools, AI-related activities, the value of mathematics and coding education in the classroom should all be covered in the questions. Gather information from these interviews with a variety of selected centers, including school directors and organizations known as STEM Power and STEM Synergy.

RESULTS

Some of the challenges in STEM education must overcome are fundamentally influenced by the student's capacity to advance their AI skills. Starting from scratch through STEM schools is advised, according to Ali et al. (2021), AI literacy for children and the findings of their research paper. They will exhibit a high level of interest and engagement beginning in childhood, which can be accomplished with the help of teachers. A source of information in the field is also the analysis of various studies. After that, a primary survey was carried out to gather information are, as follows:

1. **Increased student engagement:** According to Stinebrickner and Stinebrickner (2007), students can achieve outcomes in a lesson that piques their interest. The literature review also showed that the introduction of AI programs in STEM schools led to a rise in student engagement. According to the study, children's enthusiasm for technology will grow if they receive early assistance in mathematics and robotics. Students demonstrated increased interest in their studies, which improved academic performance through interactive and personalized learning experiences supported by science laboratories, mathematics modeling, and gaming. Teenagers' strong interest in robotics technology and science-related knowledge, which will be a useful resource for AI implementation is revealed by the primary survey.

2. **Improved learning outcomes:** Sithole et al. (2017) reported that their research revealed that

   the ability of institutions to collectively develop critical policies and practices that encourage students' enrollment and persistence during their participation in STEM programs is the key to solving the issue of low enrollment rate and attrition of STEM students.

   Also, numerous studies have demonstrated that the use of AI programs improves learning outcomes. The main survey found that because AI-based educational tools are adaptive, students showed higher retention rates and improved problem-solving skills.

3. **Challenges in AI implementation:** The main obstacles to the successful development of technology are broken down by the research into the following categories: institutional factors, student factors, and

other factors. This study mentions problems with lack of implementation despite the major difficulties (Sithole et al., 2017). The literature review found difficulties with AI program implementation. Lack of technical expertise, resistance to change, and concerns related to data privacy and security emerged as common barriers faced by STEM schools.

4. **Teaching strategies:** Teachers can mould students into productive members of society, per the findings of the "support for teachers of STEM subjects" study (Bonney et al., 2015). According to the review, implementing AI required alterations to instructional strategies. According to Yang (2022), a culturally responsive curriculum can embrace diversity and inclusivity in the teaching and learning of a variety of subjects, including STEM and AI literacy. In the interview result shows, the teachers listed this as one of the main challenges. There is a clear lack of emphasis on fundamental AI knowledge and skills.

5. **Equity and access concerns:** As noted in the review articles of STEM using ICT education the development of infrastructure in ICT sector through training from the start will be a valuable resource for Africa if it is supported by STEM centers (Barakabitze et al., 2019). The studies sparked questions about equity and access in STEM schools integrating AI. According to the review, infrastructure constraints and digital disparities may make it difficult for schools in poor areas to adopt AI programs. During the interview, as shown in the survey results, emphasized that there are limits to support in these areas.

6. **Future of AI in STEM education:** A review paper on the importance and difficulties of information technology for the future development of Africa is based on research on STEM in Africa using ICT (Barakabitze et al., 2019). The literature review as a whole pointed to a bright future for AI program implementation in STEM education. According to the primary survey results, the curriculum developed in STEM schools and considered effective in the future are generally aimed at enriching emerging learning technology, but they do not have experience in technology planning. separate AI technology.

Finally, analysis shows that absence of ICT infrastructure and policy support for its implementation is main barrier to technological progress. The institutes' responses align with interview questions too emphasizing that robot and emerging technology will receive the greatest attention going forward, rather than AI being implemented in an inaccessible way.

DISCUSSION

Results from interviews and secondary data analysis consistently highlight significant increases in student interest and engagement through mathematics and coding in STEM schools (Sithole et al., 2017). According to inspire teenagers, this suggests that efforts to encourage students to develop the knowledge and skills needed to complete STEM college courses

need to be increased. STEM school administrators have recognized that science and technology-based tools have the potential to engage students and; pay attention through individual and interactive skills learning experiences. This engagement comes from the adaptability of AI systems, as they tailor content to learners' individual needs and preferences. Additionally, Yang (2022) shows that when it comes to improving AI education, children will provide insight into new approaches to engaging in STEM and learning about the emerging technology. Students report being more motivated and interested in STEM subjects when exposed to teaching methods supported by mathematics and coding.

Data highlight positive impact of AI on learning outcomes. Teachers noted significant improvements in student achievement, especially in complex problem-solving and critical thinking. AI's ability to provide real-time feedback and adapt learning materials on student progress is considered a key factor. Also, secondary data analysis shows a consistent trend toward higher test scores and better retention rates for STEM courses that integrate AI. These findings are consistent with existing literature on AI and its potential to improve learning outcomes in STEM education. Despite promising results, challenges in implementing AI programs in STEM schools remain apparent. Interviewees discussed initial costs of AI systems, teacher training needs, and data protection and security issues. Secondary data analysis revealed instances of resistance by teachers fearing that AI would replace their roles (Bonney et al., 2015). The challenges highlight importance of considering technical and human factors when implementing AI programs in STEM education settings.

CONCLUSIONS

In conclusion, in-depth analysis of interviews and secondary data in this literature review provided valuable insights into implementation of AI programs in STEM schools in Ethiopia. The results highlight some of key opportunities, where STEM schools stand and challenges of implementing AI. The observed increase in student engagement was associated with hands-on opportunities to teach mathematics and science. According to findings, integrating AI technology into STEM schools in Ethiopia can improve children's learning experiences, so that universities can use STEM schools as a resource to develop students' abilities. Participants can learn in a more interactive way and learn more about mathematics and coding using technologies. Technological advancements can promote various skills like problem-solving, critical thinking, and creativity. The skills are valuable for overall development and future success of children in guided AI technology in Ethiopia. Proper and successful integration of AI requires teacher training in STEM schools. It is important to know how to use technology effectively and guide children to learn the basic concepts of AI. In summary, teenagers with creative skills will be able to learn the fundamentals of AI technology with the assistance of STEM associations' training programs and IT infrastructure. It will be possible to find students will create innovation on AI technology for Ethiopia in future if they receive focused instruction in this field.

Recommendations

The Ethiopian Artificial Intelligence and Burayu Talent Academy offers exceptional experiences and activities. Private institutions such as ICOG LAB, XHUB, Silicon Valley, Blue-Moon Ethiopia, and ICE ADDIS are exemplary institutions dedicated to overcoming obstacles in this field and achieving the best results for the country's AI technology development. Institutions initiated this activity to use technology and reduce dependency. In conclusion, integrating AI technology into STEM schools in Ethiopia can have positive outcomes for children and learning experiences. It is possible to produce university graduates who will perform well in the field for Ethiopia if students with aptitude in math and science classes learn the fundamentals of AI in STEM schools prior to enrolling in college. However, careful implementation of AI program, data usage and privacy; summer camp program implementation and community participation are critical to program effectiveness and sustainability. The inclusion of a summer camp program not only demonstrates the innovative nature of AI integration, but also highlights practical means by which AI can be introduced to students at an early stage, increasing curiosity and interest in STEM fields. However, teachers can responsibly and ethically integrate AI into ongoing professional development. It can be good to take advantage of the experience of developed countries, the American Camp Association research evidence of innovations that improve the experience of youth in the summer camp program, science exhibition and advocacy, hachathon and the talented youth innovator award plays a decisive role.

Disclosure of interest: The author declares that there are no competing interests associated with the research presented in this article. There are no financial or personal relationships that could potentially bias or influence the interpretation of the findings.

Ethics approval: This study does not require any ethical approval.

Availability of data: All data generated or analyzed during this study are available for sharing upon request. Interested parties are encouraged to direct their inquiries to the author, who will facilitate the provision of the data in a timely and appropriate manner.

REFERENCES

Ali, S., Dipaola, D., Lee, I., Sindato, V., Kim, G., Blumofe, R., & Breazeal, C. (2021). Children as creators, thinkers and citizens in an AI-driven future. *Computers and Education: Artificial Intelligence, 2*, 100040. https://doi.org/10.1016/j.caeai.2021.100040

Barakabitze, A. A., William-Andey Lazaro, A., Ainea, N., Mkwizu, M. H., Maziku, H., Matofali, A. X., Iddi, A., & Sanga, C. (2019). Transforming African education systems in science, technology, engineering, and mathematics (STEM) using ICTs: Challenges and opportunities. *Education Research International, 2019*, 6946809. https://doi.org/10.1155/2019/6946809

Bonney, E. A., Amoah, D. F., Micah, S. A., Ahiamenyo, C., & Lemaire, M. B. (2015). The relationship between the quality of teachers and pupils academic performance in the STMA junior high schools of the Western Region of Ghana. *Journal of Education and Practice, 6*(24), 139-150.

Girmay, F. G. (2019). Artificial intelligence for Ethiopia: Opportunities and challenges. *Information Technologist (The), 16*(1).

Guerreiro-Santalla, S., Bellas, F., & Duro, R. J. (2020). Artificial intelligence in pre-university education: What and how to teach. *Proceeding, 54*(1), 48. https://doi.org/10.3390/proceedings2020054048

Gwagwa, A. E. (2019). African (sub-Saharan) perspectives on artificial intelligence: Towards inclusive global AI governance. *Centre for Global Challenges*. https://www.academia.edu/40659264/African_sub_Saharan_Perspectives_on_Artificial_Intelligence_Towards_Inclusive_Global_AI_Governance

Gwagwa, A., Kraemer-Mbula, E., Rizk, N., Rutenberg, I., & de Beer, J. (2020). Artificial intelligence (AI) deployments in Africa: Benefits, challenges and policy dimensions. *The African Journal of Information and Communication, 26*, 1-28. https://doi.org/10.23962/10539/30361

Hobbs, R. M. (2011). *Improving problem-solving techniques for students in low-performing schools* [PhD dissertation, Temple University]. https://doi.org/10.34944/dspace/1425

Kesherti, N. (2020). Artificial intelligence in developing countries. *IEEE IT Professional, 22*(4), 63-68. https://doi.org/10.1109/MITP.2019.2951851

McCarthy, J. (2007). What is artificial intelligence? *Stanford University*. https://www-formal.stanford.edu/jmc/whatisai.pdf

Mintesnot, M. (2020). The effects of STEM Centre education on students' attitude towards science, mathematics, technology and engineering. *IEEE-SEM, 8*(7), 138-148.

Nayebare, M. (2019). Artificial intelligence policies in Africa over the next five years. *XRDS: Crossroads, The ACM Magazine for Students, 26*(2). https://doi.org/10.1145/3368075

Sithole, A., Chiyaka, E. T., McCarthy, P., Mupinga, D. M., Bucklein, B. K., & Kibirige, J. (2017). Student attraction, persistence and retention in STEM programs: Successes and continuing challenges. *Higher Education Studies, 7*(1), 46-59. https://doi.org/10.5539/hes.v7n1p46

Stinebrickner, T. R., & Stinebrickner, R. (2007). The causal effect of studying on academic performance. *National Bureau of Economic Research*. https://www.nber.org/papers/w13341

Su, J., & Zhong, Y. (2022). Artificial intelligence (AI) in early childhood education: Curriculum design and future directions. *Computers and Education: Artificial Intelligence, 3*, 100072. https://doi.org/10.1016/j.caeai.2022.100072

Suh, H., & Han, S. (2019). Promoting sustainability in university classrooms using a STEM project with mathematical modeling. *Sustainability, 11*(11), 3080. https://doi.org/10.3390/su11113080

Tamirat, W. (2021). STEM centres can elevate interest in science. *University World News Africa Edition*. https://www.universityworldnews.com/post.php?story=20210301071607880

Tikly, L., Joubert, M., Barrett, A. M., Bainton, D., Cameron, L., Doyle, H. (2018). Supporting secondary school STEM education for sustainable development in Africa. *University of Bristol*. https://research-information.bris.ac.uk/en/publications/supporting-secondary-school-stem-education-for-sustainable-develo

UNCTAD. (2020). *Ethiopia: Science, technology and innovation policy review*. UNCTAD.

Utrecht University. (2019). *African (sub-Saharan) Perspectives on Artificial Intelligence: Towards Inclusive Global AI Governance,* 1-26. Centre for Global Challenges.

Weintrop, D., Beheshti, E., Horn, M., Orton, K., Jona, K., Trouille, L., & Wilensky, U. (2016). Defining computational thinking for mathematics and science. *Journal of Science Education and Technology, 25*, 127-147. https://doi.org/10.1007/s10956-015-9581-5

Yang, W. (2022). Artificial intelligence education for young children: Why, what, and how in curriculum design and implementation. *Computers and Education: Artificial Intelligence, 3*, 100061. https://doi.org/10.1016/j.caeai.2022.100061

Yigezu, M. (2021). *Digitalization in teaching and education in Ethiopia*. ILO and JIZ.