

MACHINE LEARNING APPROACH TO EVALUATE AND ENHANCE THE TEACHING AND LEARNING IN SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS (STEM) EDUCATION

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ABSTRACT

The role of science, technology, engineering, and mathematics (STEM) in the development of any nation is very vital. these areas are important in international and national economic system, and it drives invention and improves the economy and work force improvement in gathering the recent realities. In other to achieve this aim, there is a demand for invention that will improve the economic system of the emerging time, this can only be accomplish through improvement in science and technology. The key rationale behind STEM education is to further critical intelligent skills, this would result in creating a more problem-solving workforce. The globe is tending towards a knowledge-based economic system, hence creating a problem-solvers that will provide solution to the complex difficulty of the future. This paper reviews literature in other to critically address the subject matter. A theoretic investigation of STEM education and machine learning is conducted to explain the link between the both. The central element of this report is the role of machine learning on STEM education, as rightly enacted. The Findings from this study reveals the current changes apparent globally, by and large, it is of the essence to leverage on STEM education in other to enhance any economy. By focusing more on emerging technologies. Such as artificial intelligence and machine learning, the multi-skillfulness of machine learning has brought to fore different field of computing. This Areas include, spam filtering, disease prediction, autonomous vehicles, weather forecast and optical character recognition. There are several benefits of STEM education, these has increases innovation and creativity. STEM decreases the time and challenges connected with the difficulty of teaching, by rendering an improved standardized scheme. STEM education reduces the strain connected with grading students, anticipating the future action and students' performance, and changing the ancient process of education. Lastly, the study recommends that adequate support of stakeholders is required in the learning value chain, such as teachers, students, policymakers, etc. to acquaint themselves with machine learning idea and activity. Seminars should be organized for different stakeholders in other to ensure they are rightly orientated to accept machine-learning approaches in their classroom teaching, with minimum hardship and strain.

KEYWORDS: *STEM, weather forecast, Machine Learning, Stakeholders, Disease prediction*

INTRODUCTION

The skilfulness of technology in recent times has brought about improvement and development in educational sector, it is

pivotal in guaranteeing desired learning outcomes for student. Maintaining technological development is important in providing support, creativity and problem-

solving system. Education, over time, has created a facelift and has changed the narratives in the educational system. Education over time has changed the narrative paper-based process in which students are taught without clear and standardized metrics for understanding the overall input and output of the entire learning process. Technology has assisted in creating new frontiers in STEM education, by guaranteeing improved curriculum to meet current realities, making learning more effective and resourceful (Felix and Harris, 2010).

The improvement and development of any nation depend on a strong educational syllabus that guides students on how to develop innovative capability in STEM study, vital to help students create better careers in the forthcoming time. At the heart of technology in education is artificial intelligence. This is a broad category embedding other technologies within it. Machine learning, as a major part of artificial intelligence, has been a significant part of technology for education, facilitating human interaction and learning (Felix and Harris, 2010). Machine learning is versatile, in that it is used for a variety of functions. Tomei (2013), machine learning is an innovative tool used in providing solutions for cancer, climate change, and terrorism. This highlights the versatility of machine learning in solving multiple problems.

The use of machine learning in STEM education is significant in that it can be used to review a lesson that seems difficult to understand (Lv *et al.*, 2015). STEM disciplines, which are sciences, technology, engineering, and mathematics, are often seen as difficult by students. There is a need to have a better approach to these subjects that will make it simple, fascinating, and

comprehensible, so that learning goals can be achieved. Multiple options must therefore be provided which can help the learner discover the best learning approach. Machine learning sees each student as different; and this variation is considered by seeking bespoke solutions to the individual learning needs of students. This typifies the propensity of machine learning to synergise with students, understanding their learning needs, and finding solutions to them. Machine learning also offers virtual assistance to students (Lv *et al.*, 2015) per communication. It uses communication agents that are linked to an application or a website which helps students with their needs. Therefore, machine learning has proved important in STEM education, contributing to learning along STEM lines. The study provides evidence of the importance of machine learning in STEM education, challenges of STEM education, and how machine learning can address such challenges.

Umar (2019) in his research highlights the critical role of STEM education as a catalyst for national development in Nigeria. The study emphasizes that the development of any country, including Nigeria, depends largely on the attention given to STEM education. This is because rapid economic growth is achieved through the utilization of scientific research and the application of STEM knowledge and skills in real-life situations. Umar's work underscores the importance of educational research in identifying and addressing the problems in the educational system, such as low enrolment and poor achievements in science subjects. The study concludes that for effective STEM education delivery in Nigeria, it is necessary for stakeholders to rise up to the challenges of the 21st

century, focusing on teaching methods, workload, language, resource utilization, and improving teacher quality.

Abdulraheem-Mustapha (2021) discusses the synergy between legal instruments and STEM education in the context of the Fourth Industrial Revolution (4IR) in Nigeria. The study argues that for Nigeria to reap the maximum benefits from the 4IR, its legal system must align with the principles advanced by the 4IR. This includes ensuring that laws and policies are adequate and effective to cater to the legal and policy demands of the 4IR. The research highlights the importance of educational research in bringing forth a more current and inclusive legal protection for all relevant beneficiaries of STEM education. The study recommends research collaboration across STEM fields for an integrated curriculum and an amendment of the Constitution to accommodate free STEM education at secondary and tertiary levels.

Jamali *et al.* (2023) conducted a bibliometric study to evaluate the role of STEM education in improving the quality of education. Their research provides insights into the scientific results of the role of integrated STEM education specifically in improving education quality. The study analyzes the growth and development of research activities in the area of "STEM education" and "Quality education" over a span of 27 years.

Yata *et al.* (2020) propose a conceptual framework for STEM education based on Japanese subject principles. Their framework emphasizes the distinct perspectives and thinking styles of science, technology, and mathematics. In the Nigerian context, this approach can be instrumental in defining

clear methods and objectives for STEM education, ensuring that each discipline within STEM maintains its unique principles while contributing to an integrated educational experience. This framework can guide Nigerian educators in developing STEM curricula that balance the theoretical and practical aspects of these subjects, fostering a more holistic understanding among students.

Sujarwanto, and Sanjaya (2021) discuss a conceptual framework of STEM education based on the Indonesian Curriculum. They highlight the importance of maintaining the principles of science, technology, and mathematics, while also paying attention to the interrelationship of the four STEM disciplines. For Nigeria, this framework suggests the need for a curriculum that not only focuses on individual STEM subjects but also emphasizes their inter-connection. This approach can lead to a more comprehensive and cohesive STEM education, preparing Nigerian students for the complexities of real-world problems that often require interdisciplinary solutions.

LITERATURE REVIEW

STEM Education

Historically, STEM has been a major factor in shaping education sector, there are numerous views on the origin of STEM education and its definition. Various authors and bodies have offered their own perspective on what STEM education entails, and this will be considered. STEM education originated from the works of the National Science Foundation which is affiliated to the government of the United States. STEM was initially referred to as SMET, it is an acronym for science, mathematics, engineering and technology. The major motive behind STEM

education was to engender and foster critical thinking skills, which would result in having more creative problem-solvers in the workforce (White, 2014).

The world is gravitating towards a knowledge-based economy, which requires such creative problem-solvers. The concept of STEM education is different from the conventional educational system, being predicated on integration. President Barack Obama brought STEM education into the limelight, in the drive to keep America at the forefront of innovation. Obama opined (White, 2014).

STEM education is a collaboration and the pedagogy building of skills that are needed for optimal production in the marketplace. Graduates must not only be proficient academically; they must possess apposite skills vital to the success of any enterprise. The conducting of businesses has changed globally, and the bulk of it is technologically infused. When creative abilities are encouraged in people by subjecting them to more knowledge of STEM subjects, new means and methods for addressing issue become prominent. This is in line with the views of Ramirez (2013), who maintained that creativity and innovation in STEM education develops understanding of issues from various novel and creative dimensions. With new changes coming each day, it is necessary to address such with contemporary solutions. This can be encouraged by creativity and innovation, which is the major ideal of STEM education.

More efforts should be made to ensure that all stakeholders are incorporated into the system, in other to necessitate developmental issues, especially in education, such as policymakers, school administrators, academics, inter alia,

encourage and promote creativity in conducting STEM education according to Oner, *et al.* (2016); Kim and Chae (2016); Henriksen (2014; 2017); Kang and Kim (2013); Kim, *et al.* (2012); and Tarnoff (2010). With intensified efforts towards creativity and innovation, many challenges in the world will be solved by means of STEM education. With the many and varied and changes taking place globally, such as international economic downturns, environmental issues, regional peace, unemployment. There is need for a system of education that will factor in these changes into the curriculum. Changes must be critically addressed, solving them by using the tools of creativity and innovation which STEM education promises. STEM is a method of teaching and learning that is predicated on problem/project, collaborative work, and is geared towards finding solutions to real-life challenges.

The increased demand for STEM education can be seen as an answer to the downward spiral in workforce patterns and economic indicators. The promotion of technology education in a nation during economic meltdown, in Australia for example. In that country, there is a positive correlation between economic depression and developments in technology education of the 1890s, 1930s, and 1980s. This implies that, as a panacea for economic depression, technology education has been strengthened and intensified to overcome the challenges concomitant with the economic downturn. With modern technologies, there will be a shift in workforce patterns and production processes, which will yield dividends. STEM education can help in overcoming the shortage of necessary skills in science and engineering disciplines.

Chounta (2019), in the US, there is a great demand for people with STEM backgrounds. Having a STEM-educated workforce will mitigate the many ills that have befallen the populace in the 21st century. Some of the ills have been mentioned: economic and environmental challenges, unemployment issues, amongst others. Historical analysis of each nation differs; so also does their political, social, and technological makeup. From history, each nation has developed at a different time; and this has affected the political, social, and technological structures. Accompanying these differences, are various systems of education aligned with their history. Individual countries will therefore approach STEM education uniquely, since the educational system in each country is particular to its needs.

STEM education is as a vital part of general education. STEM literacy is essential in uplifting the general populace, Felix and Harris (2010) showcased the relationship between the subjects in STEM education. The researchers commented that the application of engineering and technological design has been a helpful tool in augmenting the active engagement of students. STEM has helped in fostering learning and transfer in science and mathematics. Review of machine learning approaches

Machine learning as a discipline of study that enables the computer to learn without being explicitly programmed (Simon, 2013). This makes the computer a super-versatile tool for various functions, in line with the direction of the user. This also allows for less programming by the user of machine learning. The multi-versatility of machine learning is seen in many areas of computing, such as spam filtering, and optical character recognition

(OCR) (Wernick *et al.*, 2010), search engines, and computer vision. Machine learning and data mining are closely related. From an industrial standpoint, machine learning can be referred to as predictive analysis or predictive modelling.

Problem Associated with STEM Education

STEM education is constrained by many challenges. Tikly *et al.* (2018) highlighted some of the challenges of STEM education. Key among the impediments is the shortage of qualified teachers in the discipline. STEM education, as a discipline, relies on qualified teachers to effectively discharge knowledge to students. The need for qualified teachers was attributed to increased enrolment in secondary education. When unqualified teachers are employed to teach STEM education, STEM subjects will still seem difficult to comprehend. Tikly *et al.* (2018) further maintain that, in the sub-Saharan context, there is difficulty in factoring in the various stages of learning in individuals into the whole educational mix. Classes are often large. This does not allow for teachers to focus on individual learning abilities of students, so as to adequately address their needs. Also, STEM disciplines are capital intensive, making huge demands in terms of resources necessary for its delivery.

In other to have an effective service delivery of STEM education, computers laboratories must be available, chemicals, textbooks, should be provided, in other to have an effective system. These factors are not readily available in the sub-Saharan environment. With the lack of necessary infrastructure key to the delivery of STEM education, teachers tend to depend on theoretical approaches to learning, without necessarily

experimenting so as to have a better grasp of the discipline. There is also a societal aversion to STEM education in sub-Saharan Africa. This has engendered a widespread negative perception. According to Tikly *et al.* (2018), people are less confident of succeeding in STEM disciplines.

The Need for Machine Learning in STEM Education

STEM education, the use of machine learning could greatly create a new approach of service delivering, teaching and learning to students, placing more emphasis on the online environment. Machine learning can also help teachers to provide learning plans tailored to the needs of individual students. (Abbeel, 2016), confirmed that machine learning systems can help in automatically in comparing a student's answer with those of his peers. A situation which is a lag, machine can direct the student to the resources needed for studying a particular area. Machine learning is defined by the flexibility which tilt towards the needs of the learners by focusing on algorithms derived from massive datasets. Machine learning shows how receptive students are to information, together with their learning speed. These factors ensure that learning can only be said to have taken place when previous information has been understood by the students. This also ensures that all students are considered, and no one is left behind. Machine learning is vital in STEM education in analysing content delivered to students, using machines to instruct students. The machine-learning approach to analysing content focuses on the information the teacher uses, determining whether it is necessary to satisfy the learning needs of the students, while respecting the applicable standards. The machine-

learning approach also determines whether the information and content delivered to the students meets the intellectual strength of specific students. A large amount of data is generated in various fields of science. Machine learning is vital in processing such data sets. Machine learning is important in extending the boundaries of science. With the application of machine learning, these datasets will be applied by researchers in STEM education to analyse their datasets. In neurosciences, machine learning influences modern neuroscience through data analysis (Kass *et al.*, 2014) and through modelling techniques (Yamins and DiCarlo, 2016).

METHODS

Research Design and Literature Review Strategy

The research design for this study is centred around a systematic literature review, focusing on STEM education in Nigeria. This approach involves a comprehensive analysis of existing literature to understand the various dimensions of STEM education, including policy frameworks, implementation challenges, and comparative global trends. Ortiz *et al.* (2016) demonstrate a systematic review of literature in the context of gamification in higher education, particularly in STEM fields. Their methodology, involving a systematic mapping design and the use of literature analysis software, provides a model for this study's approach to reviewing literature on STEM education in Nigeria.

Yeboah (2020) employs a similar approach in examining contemporary AI initiatives in sub-Saharan Africa, including Nigeria. This study's methodology, which includes a detailed

examination of policy and innovation in the context of technological advancements, offers insights into the process of conducting a literature review that is both inclusive and focused on specific technological aspects within STEM education. Pratami and Kurniati's (2020) scoping review on sex education strategies for adolescents further illustrates the importance of a structured literature review process. Their use of a multi-stage review method, including the formulation of research questions and critical appraisal, is particularly relevant for this study as it ensures a thorough and systematic exploration of literature related to STEM education in Nigeria.

Komodromos (2021) provides another example of a comprehensive literature review, focusing on the impact of interactive radio and social network sites on development in Africa. This study's approach to reviewing literature across multiple online databases and using specific keywords is applicable to this study, ensuring a wide-ranging and detailed exploration of STEM education literature.

FINDINGS

Machine learning could be used in educational platforms, leading to adaptive learning platforms. Knewton is one of the largest adaptive learning platforms used by more than 10 million students globally, either separately, or with some custom-made local platforms. Knewton has a wide user base across South America, Europe, Africa, Asia, and Australia. This adaptive learning platform has improved students' retention and academic performance. However, there are tensions about how these milestones were achieved (Ferguson *et al.*, 2016). Other learning platforms include GoLab and Nextlab, which are

online experimental virtual labs supporting inquiry learning, and providing new, interactive ways of conveying knowledge to students. These learning platforms are vital in STEM education. Interactive platforms provide the opportunity for answering students' needs and concerns in STEM education. Third-space learning has its specialty in mathematics and school leadership, which are also constituents of STEM education. The application of third-space learning has resulted in an improvement in mathematics.

Machine learning is utilized in STEM education's massive open online courses (MOOCs). The application of machine learning in MOOCs is to analyse inputs of students, grading and scoring students, and their computer-based assignments. Machine learning, according to (Hollands, and Tirthali, 2014) allows MOOC handlers to provide support for students, using human resources for more profitable ventures. Machine learning is important in the educational sector, and it is vital in enhancing learning outcomes of students. The components of machine learning are used in planning, implementing, evaluating, following up, and developing objectives (Lv and Li, 2015). According to Chounta (2019), evaluating students in STEM education is imperative. Machine learning offers a viable application for student modelling and personalised feedback. Computational methods in machine learning are used to assess students' background knowledge, to evaluate students' knowledge, and to presage their future performance. Chounta (2019) further maintains that machine learning also provides intelligent methods that filter study materials and learning activities, factoring in the learners' interests and needs.

It is a Herculean task to cope with large numbers of students, evaluating them to determine their performance. Much tedious work is demanded of the teacher. A better standardization system in STEM education will reduce the stress associated with scoring students. Automated essay scoring is vital, which is one of the most promising applications of machine learning in education. Automated essay scoring (AES) is a robust application of artificial intelligence in education, using machine learning. Manually reading, scoring, and recording can be overly demanding and time-consuming. This makes many teachers reluctant to assign writing projects to their students. The major aim for AES is to score students' writing, which includes tests, assignments and exams for larger populations, such as lecture-based college courses, and for entrance examinations into higher institutions of learning. This is in line with the findings of Stone *et al.* (2016), who maintained that massive open online courses (MOOCs) applied automated scoring engines to their system to grade thousands of people learning on their platform. The efficacy of automated essay scoring has been proven to be on a par with humans, on standard writing tasks (Powers *et al.*, 2001; Kolowich, 2014).

Education has both active and passive learners. The active learner maintains an intimacy with the learning environment during lectures, whereas a passive learner is a receptor of information from the environment, without necessarily influencing or altering it. For learning to take place effectively, there must be interaction between the learners and the environment. Both paradigms used for active and passive learning vary according to the role played by the learner. Machine

learning, as a field, deals with these differences in learners to ensure that the major goal of the teaching and learning is achieved.

CONCLUSION

The word STEM (science, technology, engineering, and mathematics) has been adoptive by different program, it is a primal focus for revived global competitiveness. This will make the world live in is a single base of innovation and knowledge. In other for group to flourish in it, they must constantly align with these changes taking place. The STEM workforce will remain pivotal to our economic growth, contributing to innovation, technological growth, and economic development. Science and technology have been central players in maintaining positive economic growth and well-being among the citizens. Findings of this study reveal that, with the changes manifested in the global sphere generally, it is important to leverage STEM education. More focus on some emerging technologies such as artificial intelligence and machine learning, will promote ample benefits from STEM education. The immense benefits of machine learning, as a technology, cannot be questioned. From the study, it has been proven that this can support new ways of delivering teaching materials to students. More emphasis is now placed on the online environment. Teachers can provide learning plans tailored to the needs of individual students. This will enhance the conducting of education, fostering students' learning outcomes by providing support that will increase innovation and creativity. It will reduce the time and stress associated with the rigour of teaching, by providing a better standardization system in STEM education. Stress associated with

scoring students will be ameliorated. Future behaviour and performance among students can be predicted, and the old methods of education will change (Abbeel, 2016; Kass *et al.*, 2014; Ferguson *et al.*, 2016; Powers *et al.*, 2001; Kolowich, 2014.)

RECOMMENDATION

This paper, reviews machine learning and STEM education, together with machine-learning practices used in STEM education contexts was provided. Also, a short historical overview of STEM education and machine learning, and the imperative of machine learning on STEM education was presented. The challenges that face machine learning were also carefully examined in this paper. In response to these obstacles, the paper theorises the multifaceted benefits of machine learning in STEM education. Benefits include delivering apposite tools for stakeholders in education to choose effectively and efficiently the most appropriate resources and content that meet their learning standards. Such will ensure adaptation and customization of learning content to satisfy individual learners. This will provide a better means for evaluation, grading, and scoring students.

Technology is everywhere. It is important in the educational sector, with emphasis on STEM education. Machine learning has become a new template for education, being an innovation that controls artificial intelligence and human interaction. Machine learning has opened incredible possibilities within STEM education. This implies that future learning environments will be shaped by and are likely to be highly specific to individual learners' needs, in a bid to help them realise such needs, fostering their

potential. With the immense benefit machine learning poses for STEM education, it is vital to intensify efforts to support machine-learning strategies in the educational sphere. Such can be achieved by incorporating elements of machine learning into the educational curriculum. Machine learning is also predicated on availability of data. It is imperative that cloud-based, large structures offer centralized access, not only to pedagogical materials, but also to user data, and computational tools necessary for machine learning. There must be synergy and a bottom-to-top approach in integrating machine learning into STEM education. This will ensure that all stakeholders vital to the teaching-learning curve are considered in the whole dynamics. If good design factors in all the stakeholders, the technologies will be applicable to the context of learning. This will also ensure that there is no disconnect between the learning needs and emerging technologies and platforms for machine learning. To leverage the immense opportunities and benefits machine learning has to offer in STEM education, it is therefore recommended that adequate support be provided to stakeholders in the educational value chain. Teachers, students, policymakers, *inter alia*, must become more familiar with machine learning as a concept, and in practice. Capacity-building workshops should also be provided for these stakeholders, to ensure that they are properly oriented to adopt machine-learning approaches in their classrooms, with minimal stress. In future, machine learning will come with more sophistication that will improve learning in the STEM education context. There are possibilities of developing multiple chatbots that will provide on-the-spot solutions to learners' needs. Also,

virtual assistants will respond to the concerns of all stakeholders in the educational mix. There will be advanced algorithms leveraging the power of large datasets.

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