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The Place of Makerspace of Stem Education in Nigeria

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Abstract

This research focuses on the role of maker space in promoting Stem education in Nigeria; the target audience for the job is learners at the learning stage whose works involve invention-creation. Makerspace is an avenue for inventors to use their inbuilt talents for innovation. The word STEM means Science, Technology, Engineering, and Mathematics, a broad term comprised of disciplines under an umbrella of the word. STEM is a ubiquitous word that cuts across every facet of human existence, beginning with conception, the birthing process, activities surrounding growth and development for realizing goals, and human development in invention exercise.

STEM education is germane to the survival of different nations developing, developed, and growing; hence, the consideration of STEM education in the United States of America, for instance, has helped its citizens build a formidable education system, health care program, economy, social amenities and military strategy that drawn her strength from STEM education while in India, Italy and Singapore, we have homogenous international set of comprehensive STEM standards and education for schools based on the demography, availability of resources, qualifications of facilitators and experiences of STEM educators.

In Canada, the youths disengage from Science, Technology, Engineering, and Mathematics (STEM) studies before graduation from secondary school. This is detrimental to the growth of the nation. Therefore, the country retraced its steps, determined to prepare the youth for a future where disruptive technologies and changes in the labor market will reward highly skilled workers. While in Africa, the continent is lagging behind other continents in scientific productivity and knowledge systems. To achieve the expected stakeholders, the decision-makers focusing on education in Africa must be willing to embrace STEM education in its totality and be ready to make needed resources available for the development and growth of education in the African continent.

Keywords *Makerspace, STEM Education, Africa, Training, Skills worker*

INTRODUCTION

In this work, two terms, Spacemaker and Stem, will be defined to have a clear view of the subject matter, as Hussain and Nisha (2017) and Gonzales and Aris (2018), all conceived space makers as physical locations set up to share resources and knowledge that involve all parties toward a project. While defining the pacemaker, the Cambridge English Dictionary (2014) conceived it as a learning exercise in an innovation center where men, women, boys, or girls appropriately invent and learn an artistic work. Furthermore, it can turn knowledge into action that supports personalized learning in which young learners are motivated to use their inbuilt skills or talents to bring up a particular artistic work.

In space-making, one achievement or capacity to learn is determined by the ability to understand the primary ratio behind the project to be considered. It encourages learners to exhibit determination and expend effort to achieve particular skills or practical work. Space makers can be seen as a children's learning center where learners come together to create or invent things by using or adopting traditional crafts or technology to perform artistic work. These spaces are generally open to a broad audience, from young people to adults and other similar learners, set up in a collaborative workspace or program inside a school, library, or separate public/private facilities, offering access to infrastructure and community development.   An example where spacemaker take place can be listed as FabLabs (Fabrication Laboratories), Proto labs (prototyping laboratories), hackerspaces, mobile maker spaces (e.g.trucks), and various make-related programs and initiatives. Such terms are sometimes used as a synonym. However, over time, they have evolved different identities, habits, and communities around them that involve the following terms: Makerspaces, Maker program, Making, FabLabs, and Hackerspaces (Blackley & Hovell, 2015).

Maker spaces: is used by practitioners as any generic term that promotes active participation, knowledge sharing, and collaboration among individuals through open exploration and creative use of tools and technology. Initially, it was associated with MAKE Magazine in the US, creating tinkering spaces for children (Cavalcanti, 2013). Makerspaces do not comply with a pre-defined structure and set of personal fabrication tools whose focus is a publicly accessible creative space that explores the maker mindset and tinkering practices (Rosa et al., 2017).

The **Maker Program** acknowledges the making that takes place with or without a dedicated space. A maker program can encompass maker activities that are carried out in a conference room or a library, using a mobile cart, working out of a closet, or acting as a 'pop-up' in any corner of a museum or library, which may include 'tinkering' rather than 'making' or spaces that refer to them as FabLabs rather than maker spaces (CMP & IMLS, 2017).

FabLabs: This is the (short form for Fabrication Laboratories) space where people meet, exchange ideas, and collaborate to design and digitally manufacture custom-built objects. A distinctive feature of FabLabs is that they must comply with the Fab Charter (FabLab, 2012). All FabLabs have the same hardware and software capabilities at their core, making it possible for people and projects to be easily distributed across fabrication laboratory members in a fab-them. They are commonly set up in the context of an institution, be that of a university, a company, or a foundation. FabLabs is supported by a global FabLab association responsible for disseminating the FabLab concept and promoting collaboration among FabLabs (Rosa et al., 2017).

Hackerspaces: This is set up within a community for the community purpose -funded and managed within community- spaces. The idea behind Haberspace was to have a non-repressive physical space where people interested in programming and tinkering with technology could meet, work, and learn from each other. The spaces quickly became popular, beyond programming activities to physical prototyping and electronics. They also provide learning environment support for individuals to develop projects based on their interests. An effort is made to distance these spaces from the negative connotations of the term 'hacking' presented in the mainstream media (Rosa et al., 2017).

Makerspaces as learning exercises can offer access to high or low-tech equipment and an engaged community of makers who can provide the ' know-how' to a particular invention (Dougherty, (2016). The central issue in maker space is access to technology, which often has non-tech activities,

e.g., arts and crafts creating prototypes and designs in the analog phase or moving back between analog and digital. In their different forms, maker spaces have other targets to support social innovation, inclusion, lifelong learning, creativity, arts, and culture; training unemployed people and empowering certain groups, including women and young people; developing skills, including digital skills, Engineering and Entrepreneurship as well as innovative education in schools.

ASPECTS MAKER SPACE IN EDUCATION AND TRAINING

Learning in maker spaces may occur in formal education and learning with different aspects that make them appealing to education and training.   Firstly, it is an interdisciplinary aspect, and secondly, by solving authentic, real-world problems, individuals acquire new knowledge and create meaning from this experience. Thirdly, flexible learning arrangements span from peer learning, peer mentoring, peer coaching, and peer teaching to more structured workshop demonstrations of tools. This unique feature of maker space makes it an appealing argument for implementing maker spaces in education and training, where disciplines are traditionally taught in theory and practice. A case study of maker spaces highlights the following: "This blending of traditional and digital skills, Arts and Engineering combines that lead to a learning environment with multiple entry points to participation and leads to innovative combinations, and uses of disciplinary knowledge and skills." (Kids and Tech, 2021). In the same vein "people working in one [discipline] area may be looking at someone in another, and drifting over to get involved in another discipline to replicate the interdisciplinary ethos of maker spaces, a plethora of maker spaces has been created to pursue Science, Technology, Engineering, Arts, and Mathematics (STEAM) learning outcomes within both formal and non-formal education. Moreover, maker spaces may focus on robotics, STEM subjects (Science, Technology, Engineering, Math), and Arts and design that can help foster a link between education, innovation, industry, and real-world applications. Lastly, maker spaces could also create a conducive environment as an incubator for future social innovations and business start-ups individual.

Thus, a maker space workroom can be seen in Figure 1 below, where everyone is involved in one activity or the others.

Figure 1. Students in maker space workstation

GLOBAL PERSPECTIVE OF STEM EDUCATION

The word STEM is an acronym word that stands for Science, Technology, Engineering, and Mathematics. It is a broad term that brings different disciplines together under an umbrella. STEM is ubiquitous and cuts across every facet of human existence, beginning with the choice of conception, the mode of birthing, the selection of toys for a child, and the option of a school that

helps in curriculum planning, development, and choices in schools. It goes further to determine the choice of vocation by individuals, which influences a nation's workforce development, the citizens' security, financial policies and development, and others.

STEM education is an aspect of STEM in the education system. It is the bringing together of science, technology, engineering, and mathematics disciplines in a practical and simplified way using it yourself approach to develop a desire for investigation and findings in learners and building in them a team spirit because collaborating with peers and other disciplines that are not in STEM to achieve set goals essential in STEM education. Breiner et al. (2012) opined that STEM education is a variety of activities that include more inquiry and project-based teaching strategies instead of conventional lectures. In the words of (Ntemngwa& Oliver, 2019), STEM education is the interdisciplinary approach that merges two or more STEM subjects into a project. (Blankley and Howell 2015) further define STEM education "as an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that bring about connections between school, community, work, and the global enterprise, enabling the development of STEM literacy and with it the ability to compete in the new economy."

STEM education imparts students in four disciplines by integrating them into an interrelated learning pattern on the real-world application; it begins while they are very young. What assorts STEM education from conventional science and mathematics education is the blended learning setting and imbibing in students how the scientific method can be applied to everyday life. It is pertinent to the survival of every developed, developed, and growing nation, hence the look into the state of STEM education globally. For example, the United States of America is known as a world power. It has always drawn strength from STEM education for its citizenry, and this helped to build a formidable education, health care, economy, social amenities, and military system; it is currently discovered from research that there is a decline in their STEM education because not enough youths have access to quality STEM learning opportunities and too few students see these disciplines as springboards for their careers. Highlighting the level of   STEM education in the United States of America (USA), Kocabas et al. (2019) compared them with other nations. It was discovered that students in elementary and secondary schools have relatively mediocre scores compared with their international peers. However, they performed better than earlier American cohorts in science and mathematics. This is because most of their STEM educators still need a degree in the subject they teach. In the mandate of the Department of Education of the United States of America, it is stated that "all young people should be prepared to think well and deeply so that they can have the chance to become the innovators, educators, researchers, and leaders that can solve the most pressing challenges facing the nation and the world today and tomorrow."

To get back on track with STEM education in America, it was decided that reinforcing curricula and educational programming focusing on science, technology, engineering, and mathematics will help better prepare students in the areas of learning that they are lagging and creating practical applications for how these lessons are to be applied to the real world. Also, employing STEM educators with the right qualifications for the subject taught is of great essence in the United States of America now because STEM education is designed to encourage students to pursue these subjects, innovation, and career paths. This focus will help prepare future generations to handle the world's biggest problems best.

Furthermore, in Singapore, technology and initiatives such as robotics are implemented in early childhood learning to prepare students for future challenges and to enhance their contribution to the nation's development. (Sullivan and Bers, 2018). In a research carried out by Tawbush et al. (2020) comparing STEM education in India, Italy, and Singapore, it was discovered that there is no homogenous international set of comprehensive STEM standards education for schools. They vary based on the demography, availability of resources, qualifications of facilitators, and experiences of STEM educators.

However, previously in Canada, most youths disengaged from science, technology, engineering, and

mathematics (STEM) studies before graduation. Still, the government realized it was detrimental to the nation's growth and retraced its steps. It was determined to prepare them for a future where disruptive technologies and changes in the labor market will reward highly skilled workers. Thousands of Canadians contributed to developing the Canada 2067 learning roadmap, a set of key recommendations to ensure Canadian youth will be prepared to contribute and thrive in an ever more complex and technologically intensive world. (Schmidt, 2019) elucidate that "students and youths in Canada are now given a goal to develop a full range of skills needed to navigate an increasingly complex world and have equal opportunity to pursue diverse career paths."Which can only be achieved through a formidable STEM education that the country is investing in. Students in Canada are currently engaging in meaningful science, technology, engineering, and math (STEM) learning opportunities to develop the skills and abilities needed to become creative, critical thinkers, entrepreneurs, problem solvers, and informed citizens.

The perception of STEM education in Africa was summarized by Formunyam (2020) in research on massifying STEM education, which discovered comparative indicators revealing that Africa is lagging behind other continents in scientific productivity and knowledge systems. He proposed massifying STEM education as a countermeasure to enable Africa to meet the global competition and prepare for the future. Through several strategies, Massifying STEM in Africa involves creating access to creativity, innovation, and invention. This increases the enrollment of students in STEM subjects and fields of great essence. To achieve this, stakeholders and decision-makers in education in Africa must be willing to embrace STEM education in its totality and must be ready to make needed resources available.

Globally, students now understand that the world is changing at an unprecedented rate and are enthusiastic about the opportunity for the school to be a learning environment for everyone, including teachers, administrators, and students; therefore, exposing them to needed skills early is essential. Ubawuike (2018) quipped that "equipping learners with twenty-first-century skills is the current pursuit of nations of the world." to achieve this, STEM education is indispensable, but the global state of STEM education is complex to ascertain due to the lack of uniform resources both human and physical, environment, implementation, and standard and different demography.

STEM EDUCATION IN NIGERIA
Education can be defined as acquiring knowledge through learning, which can be done within the walls of a school or outside an academic environment. In both instances, an instructor can impart the process directly or indirectly or peer-to-peer. The education system in Nigeria is divided into 6-3-3-4 (six years in primary school, three years in junior secondary and senior secondary school, and a minimum of four years in a tertiary institution, depending on the course of study). It is in this system that STEM education is enmeshed.

STEM education is critical to the growth and development of a country on all fronts, and Nigeria is not an exception Oyebuchi et al., (2017). It is established from research that STEM education in Nigeria is not a new phenomenon but has different nomenclature as it evolved before Nigeria got her independence when the British curriculum was used in our education system. Ugwu et al. (2011) elucidated that STEM education reform in Nigeria can be traced back to the period of the Second World War with the school system changing from the British curriculum to our traditional curriculum; he observed that despite the change in curriculum, STEM education is yet to find its rightful place in the curriculum and STEM subjects that are taught individually in our schools without integration which makes STEM education to have lost its purpose, this is because STEM educators are not involved in curriculum planning and development in Nigeria, they work with curriculum developed by others to teach in class which does not project the purpose of STEM education. He advocates for the training of STEM educators and that they should be allowed to actively participate in curriculum planning and development of STEM education to be well projected and achieve its purpose and for the overall success of STEM education.

STEM is hoped to engender socio-economic development through opportunities for employment, income benefit, and welfare improvement and to foster scientific skills capability and habit to solve

problems coupled with imaginative, creative thinking and general mental prowess. However, it is evident that, as of today, these lofty goals of STEM cannot be said to have been satisfactory in Nigeria, considering the level of development and massive unemployment of graduates, the supposedly 'STEM' technocrats. Referring to the improvement of STEM in education in Benue state, Nigeria, Ugo (2016) observed that mindset rather than skills is the major obstacle to students and teachers in improving STEM and related subjects to embrace a new innovative teaching approach. Furthermore, Ugo (2016) stated that any nation that adequately considers STEM in its education and economic planning will be included in the development terrain. The contribution of STEM spans another aspect of human life apart from the four major components that STEM is known for. However, it is now felt in all indices such as social, industry, and economic life of the world and Nigeria in particular to solve the problem of human interaction.

Tracing the subject of the evolution of Education as related to Nigeria, Umar (2019) opined that the development of any nation is determined by a combination of Science, Technology, Engineering, and Mathematics because rapid economic growth is made possible through the utilization of scientific research coupled with STEM knowledge and skill in real life situation, in this aspect one can say that Stem plays an essential role in the promotion of national development. The literature on STEM is abounding. For example, Adikwu et al. (2017) counseled that for any nation to develop its Science and Engineering infrastructure to transform its citizen's quality, it must depend on donor countries and international partners to assist them, especially the African nation. However, in contra, Uswantun (2020) stated that the basis of the literature review on the STEM education definition is broad and depends on the stakeholders during implementation.

However, Ubawuike (2018) reiterated that equipping learners with twenty-first-century skills is the pursuit of world nations now; therefore, STEM education is of great essence to them, and they integrate STEM subjects when teaching because they see them as meta-disciplines. However, in Nigeria, they are taught independently with a focus on mathematics and science in secondary schools, while technology and engineering are taught in tertiary institutions, which is relatively late. He suggested a repositioning of STEM education in Nigeria. Consequently, there are lots of bottlenecks in our education system that are not making STEM education thrive as it ought and thereby causing setbacks in our development as a nation such as teachers not teaching the subjects they are trained to teach in class; many schools do not have sufficient teachers and professionals, teaching STEM subjects independently and not been integrated into the curriculum, not having specially trained teachers and educators for STEM education in our schools, obsolete science equipment in our schools and some cases some schools do not have at all, students are subjected to alternate to practical which is theoretical; some students are only privileged to see a beaker physically when they are in the university. For STEM education to take its place in Nigeria, whereby Nigerian students will be able to compete effectively and efficiently with their peers in other countries, the government needs to see STEM education as imperative, make resources available, and designate teachers who are experts in the field to take, if there is need to retrain the teachers our government should not shy away from STEM education and allows students to think critically and deeply to create things using hands-on and individual experience which they bring into collaborating with others and building a team of innovators and inventors that brings about significant development of the nation.

A typical example of STEM education is demonstrated in Figure 2 below, where every member of the STEM team performs one activity or the other to arrive at a point of getting something done.
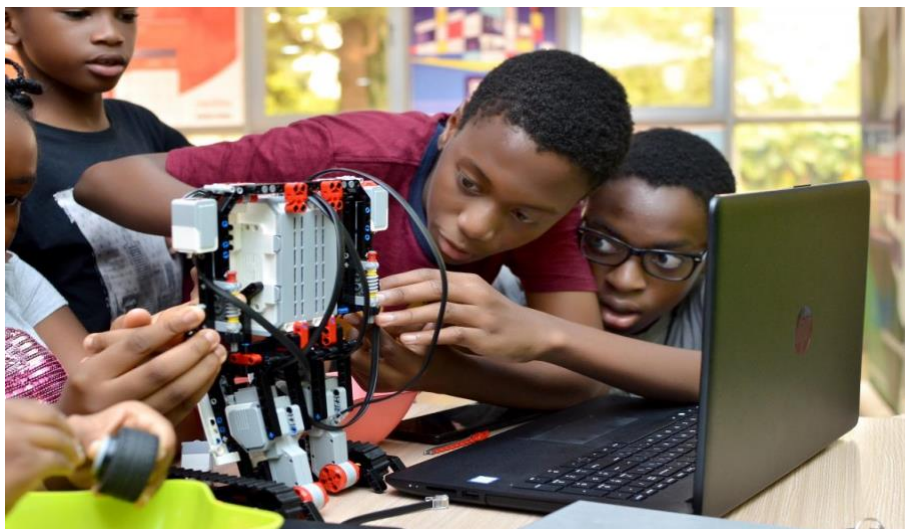
Figure 2. Stem education in Nigeria

MAKERSPACE IN STEM EDUCATION

What is Makerspace?
Makerspace is a designated area for making things (inventing) with available and provided resources. The space can exist uniquely in a library or a classroom. It allows learners to think deeply for them to become innovators and inventors by doing it independently with guidance from their instructors or teachers. Velasquez (2018) described a maker space where learning and discoveries occur casually and collaboratively using hands-on arts and technological education. It is defined in the Cambridge Dictionary "as a place where people can come together to create or invent things by either using traditional crafts or technology."

Makerspace focuses on STEM education subjects science, technology, engineering, and mathematics, combining them with crafts, arts, and design to make, create, and invent things. For maker space to be fully enmeshed in STEM education, teachers and learners must be able to think critically and deeply, diversify, create, and collaborate. In the European framework of critical competencies for lifelong learning (EU, 2019), the ability to create, collaborate, problem-solving, digital competencies, and entrepreneurship are attributes that makerspace educators should possess to make them relevant to STEM education and to be great inventors which they will subsequently impart on their students. A report titled "Overview of the make movement in the European Union "presented by Rosa et al. (2017) expressed the activities of maker space in education; from the report, 826 maker spaces across the 28 European Union countries were identified, ranging from digital fabrication, programming, electronics, design, arts, education, biohacking to entrepreneurship and environment in which western European countries (France, Germany, Italy) own a more significant percentage of the identified maker space.

Furthermore, Makerspace and STEM education are relevant, and this relevance is beginning to gain the attention of educators, librarians, and school library media specialists to spice up their teachings and make their library homely, creating makerspace, discussion space, etcetera in the library. One attribute that makes them relevant to each other is their interdisciplinary nature. While exploring, students acquire new knowledge and create meaning from this experience. Makerspace is also known for its flexible learning arrangements, which can be peer-to-peer, peer mentoring, peer reading and teaching, and diversity of learning arrangements. The compatibility of maker space activities with the curriculum is another aspect that connects it to STEM education and availability to all learners, regardless of age. Also, they should be introduced early to learners to be well grounded in it. Referring to when Makerspace and STEM education should be submitted to learners, Marshal et al. (2019) opined that maker space and STEM education should be introduced from kindergarten and when they should be well equipped for learning tasks ahead of them. Another attribute of STEM education and maker space that makes them interrelated is that they are

interwoven, and science, technology, engineering, and technology are their core. Carmichael (2017) opined that STEM is interdisciplinary, content-specific, integrated, and a combination of other subjects. Therefore, drawing a line between maker space and STEM education is a herculean task for educational planners. However, they must cut across different fields of learning and profession, including School Library Media, where information professionals known as Media Specialists coordinate the activities of such a center. Then, what is the role of media library Specialists in maker space? Their role is listed below, as highlighted by professionals in the field.

ROLES OF SCHOOL LIBRARY MEDIA SPECIALIST IN MAKERSPACE

A school library media specialist is a resource and educational specialist who collaborates with educators to provide equitable access to resources and information for students and staff of a school. Describing school library media specialist Oyewusi (2016), a school library media specialist is a librarian who is a certified information professional in the areas of the school library and a teacher who is a specialist in the school curriculum. The school media specialist occupies an important position that makes them exert themselves more than the conventional librarian; they possess the money on how and where to get their information and information resources for the children and young adults, and they are knowledgeable and well-informed on the areas information resources and needs of children and young adult.

The above attributes enable them to carry out their dual obligations, which are creating a maker space and seeing to it that it fulfills the purpose of its creation in the school library media specialist professional fulfillment.

1. They are significant stakeholders in the maker space who are deeply involved in keeping the library relevant resources to the activities and projects of the school library or parental body (Oyewole & Igninovia, 2017).
2. School library media specialist teaches and collaborates with learners and other learning community members to analyze learning and information needs (Oyewusi, 2016).
3. They understand the needs of students and seek their input in creating maker space and deciding on activities to be carried out by sending out formal letters to them and their parents or having informal discussions with them.
4. They are pathfinders to the makerspace by incorporating STEM subjects into library makerspace and coming up with innovations for things that can be invented.
5. The school library media specialist generates bookmarks or index-sized cards, mini-pathfinder, further book ideas, websites, and community places or events that can encourage learners to continue researching after leaving the maker space (Preddy, 2013).
6. Educational leaders and resource specialists collaborate with other educators to provide all team members equitable access to resources and information.
7. They are instructional partners (McCracken, 2001; Church, 2008; Oyewusi, 2016). Since school library media specialists are primary custodians of knowledge and resources, they must be included in the makerspace.
8. They constantly explore ways to engage learners in thinking, creating, sharing, and growing; therefore, they are expected to be active partners with the educator(s) in the makerspace (Julian & Parrott, 2017).
9. They are utility players and can play several roles competently and conveniently (academia, administrator, technologist, educator, scientist, etc.
10. They play the role of a co-educator or instructor in the maker spaces. This can be achieved by creating activities that nurture critical thinking and learning and creating new assignments that enlighten the learners' understanding of the course content and encourage students to investigate new media. (Lippincott et al., 2014).
11. They play the role of a program administrator in a maker space. This entails developing and implementing goals that reflect the objectives of the maker space, regular communication with fellow administrators, and management of space, equipment, and resources (Oyewusi, 2016).
12. They access technology to acquire first-hand knowledge and current information to maintain relevance in the maker space activities. It provides guidelines on online resources such as databases and serves as the technology coordinator of the makerspace.
13. They provide guided instructions to learners. As much as creativity and critical thinking are

required in a maker space, the place of education must be followed. Samples of clues that appeal to the various sense organs can be made available to guide maker space activities. Some of these clues may include texts, visual, verbal, and kinesthetic. Instructional drawings or graphic designs can enhance learning, including illustrations, texts, or even videos. Learners can also be involved in creating these instructional materials (Preddy, 2013).

14. They are activity planners in a maker space and consider activities that could be individual make-and-take or group construction (Preddy, 2013).

15. They are ideas generators and inspiration in a maker space by creating and generating activities that may be original ideas received from a partner or discovered during personal study and research. The inspiration for activities may come from a lesson plan, holiday, commercial, professional conversation, event in a fiction read, a visit to a place, or any of the casual, everyday experiences (Preddy, 2013). The school library media specialist must develop activities that invite curiosity, encourage playfulness, and be creative with tools available in the maker space (Oyewole, 2017).

Figure 3. School library media specialist in maker space

CHALLENGES IN IMPLEMENTING MAKERSPACEBY MEDIA SPECIALIST
Nothing in a human organization or life is perfect without its challenges, and as good as maker space is, its evolution is not without its challenges. Some of the difficulties of Makerspace are:

Safety: This is essential as it determines how the makerspace will be designed and used; if there is a mistake from the beginning, it can pose a danger to everyone. When Safety rules are clearly stated and displayed, some maker space users may not abide by them, which may affect the invention in the long run.

Storage: When a maker space is created from an existing area where tools are kept, it can be challenging and should be planned alongside the maker space.

Financing: Makerspaces sometimes require an additional budget that many libraries do not need; the provision for getting the money can be challenging. Slatter and Howard (2013) elucidated that library budget constraints create challenges in the purchase of expensive technologies for maker space programming,

Staffing and Scheduling: When maker space is created in a library, more hands will be employed, but integrating them into the existing workforce may be challenging. Makerspace tends to be time-consuming and difficult, especially if the maker space staff compares themselves with library staff and feels cheated.

RECOMMENDATIONS
Conclusively, from existing literature, it has been discovered that STEM education and maker space is a universal global norm. However, with different nomenclature, the aim is to use the platform of science, technology, engineering, and mathematics as a pedestal for a nation's remarkable all-round growth and development. Therefore, it should be taken seriously by all and sundry, from learners

to government, policymakers, and decision-makers. To attain this, the following recommendations are being suggested.

- STEM education and maker space should be introduced in schools from kindergarten.
- Specialists in STEM subjects should be allowed to teach the subjects.
- STEM subjects should be integrated when taught rather than independently.
- STEM educators should be involved in curriculum planning and development.
- Parents should endeavor to create maker space Corner in their homes.
- Countries that are lagging should collaborate with other countries on STEM education.
- Boot camps should be created where children can be more exposed to maker space and STEM subjects.

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