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Learner Perspective of Pedagogy for Improved Performance in Stem Subjects: A Literature Review

Judah M. Ndiku[1], Veronica Kaluyu[2]
[1]*Department of Educational Planning and Management Masinde Muliro University of Science and Technology*
[2]*Chandaria School of Business United States International University-Africa*

Abstract
Science, Technology, Engineering and Mathematics (STEM) instruction has gained prominence in the education circles because of the need to transform economies and educators have attempted to develop integrated instructional programs to actualize this. This has been informed by the poor performance in the STEM subjects which has largely blamed on the traditional learning processes whichhave taken the form of direct transfer of knowledge from the teacher to students/learners. The teacher centered approach has been criticized for not actively involving learners. Indeed students learn better if they are actively involved in the learning processes. This review, discusses the pedagogical issue affecting performance in STEM subjects from a student perspective. The student related factors, affecting performance in STEM subjects are addressed and the plausible interventions to improve on the performance in these subjects. The main search key themes included: students' pedagogical beliefs and attitudes, IT access and integration, ICT skills capacity interventions, cloud digital content and academic and performance in STEM Subjects. In the review the researchers analyzed the literature drawn from both qualitative and quantitative studies from different sources such as Emerald, Taylor and Francis, JSTOR among others. The review clearly found that to transform performance is STEM education, there is need to employ new learner friendly pedagogies and embrace ICT integration in the learning of STEM subjects, institute interventions in skill capacities among teachers and learners, the need to access digital content in the cloud and need for ICT integration in the learning of STEM subjects. The study findings are an eye opener for further research and capacity interventions for students and teachers to improve learning in STEM subjects.

Key words: ***Academic performance, STEM Education, ICT integration, Performance, Pedagogy, Learning, cloud digital content.***

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I. Introduction

Pedagogy in Science, Technology, Engineering, and Mathematics (STEM) subjects globally, has taken a center stage where education researchers are interested in how learning of these subjects should be conducted(JICA, 2013). This has culminated into recommending innovations in instruction and adopting more learner friendly pedagogies. Along with this is the need to modernize the teaching of STEM in schools through mainstreaming,utilization and adoption of Information Communication Technologies (ICTs)(Mbugua, Kiboss &Tanui 2015) to change the way instruction has been conducted over the years and make learning more interactive and interesting to the learners and avert the poor performance in the STEM subjects.

Dismal academic performance in the Kenya Certificate of Secondary Examination (KCSE) in mathematics and science subjects has been registered over the years (Kenya National Examinations Council (KNEC) Reports, 2008; 2014; 2015; 2016 and 2017). In 2016, nearly 90% or 493,184 of the 569,733 candidates who sat for the mathematics paper scored between C- and E grades. This was consistent with performance in science subjects. For instance, in Biology a total of 509,822 candidates sat for biology but only 71,348 scored C+ and above while in mathematics, out of 570,278 candidates 63,813 scored C+ and above. In Physics, out of 149,782 who sat for physics only 50,596 qualified. In 2017 and 2018, the situation did not change much. In 2017; 545,014 candidates sat for Biology but only 1,503 scored C+ and above; in Mathematics out 609,495 candidates only 3,926 scored C+ and above. In Chemistry 606,006 candidates sat for the exam but only 54,925 scored C+ and above while in 2018 in Mathematics, out of 653,549 candidates 98,219 scored C+ and above; Biology out of the 584,924 candidates only 33,126 scored C+ and above; while in Chemistry out of the 650,898 candidates who sat for the exam only 73,566 scored C+ and above (Wanzala, 2019).

Several reasons have been advanced as the main contributing factors to the poor performance. They include; under staffing leading to heavy work load among teachers, class size inadequate teaching/learning materials, poor teaching methods/skills lack of motivation and negative attitudes by both teachers and students,

retrogressive practices, lack of frequent practice by students, influence of previous poor performance and in some instances(Amunga & Musasia, 2011;Mbugua *et. al*., 2012; Bunyi, 2004; JICA, 2013;Karigi *et al*.,2015;Katiambo *et al.*, 2019).(Konyango *et al.*, 2018), confirm the same in the performance of Physics where it they established that inadequate qualified physics teachers, inappropriate laboratory equipment necessary for effective teaching of physics were the main causes for the students' poor performance.(Konyango et al., 2018)further argue that other contributing factors to the poor performance are; utilization of teacher-centered instructional strategies, teachers' and students' negative attitudes towards physics and acute shortage of appropriate physical resources, especially text books and laboratory equipment.

Efforts to address the challenges in the teaching and learning of mathematics and science subjects have been made to avert the dismal performance. Such efforts include the Strengthening of Mathematics and Science in Secondary Education (SMASSE) programs and also encouraging research in the subjects aimed at finding strategies to improve the learning and performance in mathematics(Katiambo *et al.*, 2019;Wanjala, 2016). The aim of the SMASSE project is to capacity built the teachers of science and mathematics, to improve understanding of concepts and performance in these subjects through In-Service Education and Training (INSET) sessions for teachers with an innovative approach(JICA, 2013). Despite the efforts, performance in the STEM subjects is still low where majority of the students' grades are below the expected level.

Despite the training of teachers and capacity building them through the SMASSE programmes in Kenya, just like elsewhere in Africa, the problem of learning STEM subjects still abounds. One wonders whether the teachers reach the students during instruction. Learner friendly pedagogies like, project-based learning where students are involved in problem solving is minimal. Other challenges of learning in STEM are; poor teaching materials which at times are not attractive to the learning process as learners do not get along with teaching materials that are not designed to provide clear guidelines for classroom activities(Ejiwale, 2013). Poor content delivery and methods of assessment are also an impediment in learning STEM subjects. Assessment should not only be based on the cognitive domain alone but also should include affective and psychomotor domains something which is minimal in the current assessment of STEM subjects. Students have also complained about weak peer mentoring opportunities where teachers do not give the opportunities to learn from one another. Students have also complained of lack of a variety of teaching methods especially integration of ICT in learning and carrying out assignments(Ejiwale, 2013).

1.2 Problem Statement

Kenyan students like elsewhere in Africa(Kafata, 2016) seem to lack motivation and interest in learning, especially in mathematics and the sciences. Interest is a feeling of like or dislike of an activity and it is concerned with the choice or preference of a particular activity. It is the zeal or willingness in an activity for which one derives pleasure(Gambari, Falode, & Adegbenro, 2014). Researchers such Ifeanacho, 2012; Katiambo *et al.*, 2019;) have blamed the poor achievement in mathematics and sciences on the use of inappropriate learning strategies which are mostly teacher centered. Such strategies usually lead to lack of interest and retention of scientific and mathematical concepts.

To effectively learn in Science and Mathematics, there is need for more learner centered strategies such as Problem Based Learning (PBL) experimentation and utilization of ICT as innovative STEM educational practices, including the pedagogical use of ICT in learning(Osman & Saat, 2014).Utilization of ICT pedagogically, enhances students' learning outcomes and digital competence and it is a major element in making science studies and careers more attractive for students (Noor-Ul-Amin, 2003; European Schoolnet, 2017;Mlambo, Rambe, & Schlebusch, 2020).ICTsprovide multimodal features that enable flexibility and interaction in learning at individual and group levels among learners (Lawrence and Tar, 2018).Use of ICT in instruction can add value to children's investigations and learning, especially when it's used in ways that increase access to high-quality content and encourage peer interaction. ICT has a positive impact on students' perceptionstowards STEM subjects, and can ensure that students are digitally competent when they leave school (European Schoolnet, 2017).Use of ICTs also has the capacity to meaningfully engage learners in problem solving and critical thinking(Cazorla & Kurt, 2019). Further, besides improvements in examination scores, adoption of ICT in the teaching and learning processes is strongly associated with increased interest in sciences among learners, influence students' attitudes and interest towards STEM and positively affects their achievements and retention(Mwaruma, 2015;Yusuf & Afolabi, 2010)as ICTs are systematic and can be used to mobilize teachers' creativity and make their deductive practices more flexible and ingenious(UNESCO Institute for Information Technologies in Education, 2004).

There is therefore need for utilization of ICTs in learning as they provide opportunities for students to learn a variety of learning methods such as; drill and practice, tutorial, games and simulation, animation, among others and also it enables the learners to search databases, interpret models, and critique electronic resources to succeed in school and in the workplace (Chinyere & Ifeanacho, 2013). When ICTs are utilized in instruction, students are no longer the traditional passive recipients to learning initiators, rather through ICTs, learner-centered approaches to instruction comes into play and teachers become facilitators of student learning through

contextualizing and monitoring ICT-based learning functions. A variety of ICT aided pedagogies which have been found to promote learning in STEM from learners' perspectives include but not limited to; inquiry based learning, project-based learning, blended learning, mobile learning, flipped learning, robotics, 3D computer-aided design systems and massive open on-line courses (Savec, 2019). Further, availability of digital information in the cloud enables flexible learning, ease of sharing of information and innovative ways of accessing more information. The Literature Review presents the pedagogical issues surrounding students' poor performance in STEM, articulating the pedagogical skill gaps in learning of STEM, skill capacity interventions, students' perspective on access to ICT and how availability of digital content in the cloud can enhance learning in STEM.

1.3 Purpose

The purpose of the review was to identify the challenges students face in the learning of STEM subjects and suggest the pedagogical interventions to build students' capacity on the integration of ICT in learning in STEM. Such capacity building will include use of ICT by improving students' competence in ICT use, and utilization of digital content in ICT integration in learning in STEM. In the following the following objectives were addressed.

1.4 Objectives

1.4.1. Pedagogical beliefs influencing students learning of STEM subjects
1.4.2. Factors for Skills gap on utilization of ICT in learning of STEM Subjects
1.4.3. Plausible students' skills capacity interventions on the use of ICT integration in the learning of STEM subjects
1.4.4. Access of ICT in schools onstudents' perspective on learning of STEM Subjects
1.4.5. Influence of availability of digital content in the cloud in the learning of STEM subjects

Theoretical Basis

The study was based on constructivist learning theory as propounded by the works of Seymour Papert (1928- 2016)among constructivists which has had wide ranging impact on learning methods in Science and Mathematics. In the constructivist context the learner is consciously engaged in constructing an entity through active participation in the learning processes. According to Symour Papert for learning to take place learners should be involved in the learning process by developing activities that are rich in scientific, mathematical, and other contents like managerial skills and project skills, and which mesh with interests that particular kids might have. Most constructivist models, stress the need for collaborative learning among learners. The theory has influenced the replacement of teacher based approach with learner based pedagogies which are learner centered, hands – on and group work. Seymour Papert advocated for classroom activities where the teacher is learning at the same time as the learners and with the learners.He argues that; unless teachers do that, they willbe boundby the limited knowledge of what they were taught to do when they went to school. Seymour Papert was also an advocate of the use of computer technologyin learning.Papert and Solomon(1971)observe that computers can be used to do many things in the learning processes. They observe; computers can established to move a machine called a Turtle in geometric patterns, play games, draw diagrams, make movies, program musical instruments and compose music, computerize erector sets, make light shows, write poetry, teach physics, and control puppets among other things. In the works of Papert this review finds a bearing in advocating for learner centered pedagogies and application of computer technologies in learning.

II. Methodology

A narrative literature review approach was used. In this review, scientific articles were selected based on pedagogical factors that influence poor performance in STEM from a students' perspectives. The, review collated and compared studies published between 2015 and 2020 on pedagogical issues influencing poor performance in STEM subject.The reviewidentified, critically evaluated and summarized the findings of all relevant studies describing addressing the objectives of the study (Ganeshkumar & Gopalakrishnan, 2013)**.** The search criteria used for this review consisted a critical search of literature based on the research objectives. This was done by rephrasing the research objectives into research questions and a google search was done for all articles, unpublished thesis or projects, critical literature review and book chapters fitting the objectives.

2.1 Inclusion and exclusion criteria

In this review the studies that were included needed to be current and relevant to the research objectives. Included were articles published between 2015 and 2020. In the search, it was observed that there were very few studies with student opinions. The reviewer included experimental and quasi- experimental

studies where students took tests. Included were also studies where students gave opinions along with other stakeholders such as teachers and parents. The studies that were excluded during this review included those that were old that is published before the year 2015. Those studies whose focus was outside the scope of this review were also excluded. Excluded also were studies that were unrelated.

2.2 Data Evaluation and Analysis

All reviewed articles were evaluated to assure quality by examining whether the purpose and objectives were articulate including rationale; the literature review was articulate and relevant; relevant theoretical frameworks was used; the participants are well identified; the methods, that is the instruments, their administration and data analysis are relevant and finally the results and conclusions address the problem. Thematic approach was used in analyzing the data where data was examined to identify common themes guided by the key search words and phrases obtained from the guiding research objectives.

III. Findings

The findings of the review guided by the study objectives were summarized in this section.

3.1. **Pedagogical beliefs influencing students learning of STEM subjects**

Table 3.1 presents some key studies illustrating key findings on the factors contributing to poor performance in STEM subjects and some of the preferred pedagogies to improve learning in STEM.

Table: 3.1: Factors for poor performance in STEM and preferred learner centered pedagogies

Author (s)	**Factors**					
	Attitude	*Motivation*	*Learning strategies*	*Content relevance*	*Fear/ lack of confidence*	**Preferred Pedagogies**
Dean Cairns, D &Areepattamannil, S.(2019)	√	√	√			Blend of: Teacher-directed and Inquiry-Based Learning
Sari et al, (2017)	√	√	√			Problem Based Instruction
Mustafa, (2017)	√	√	√	√	√	Problem Based Approach ; Cooperative Approach
Hanif, et a(2019)			√			Project-Based Learning
Yildirim & Turk, (2018)	√		√			Problem Based Learning
Pale, (2016)	√		√			Student Based eg. PBL
Fakomogbon, (2017)			√			Collaborative learning
Olabiyi & Awofala, (2019)			√			Cooperative Learning
Wekesa, N. W. Ongunya, R.O. (2016)	√		√			Project Based Learning
Beier et al., (2019)	√					Problem Based Learning
Pedaste, Leijen, Saks, De Jong, & Gillet, (2017)	√		√			Multiple approaches
Garneli, Giannakos, & Chorianopoulos, (2017)	√					video game pedagogy
Bernard, R. M et al, (2019)	√		√			Student-Centered learning
Ohadugha, R.O. Chukwuemeka, E.J. Babatunde, A.E.(2020)		√				Peer Mediated Learning

3.2 Factors for Skills gaps on utilization of ICT in learning of STEM Subjects

Table 3.2 presents some studies discussing the factors contributing to skill gaps on utilization of ICTs in learning STEM and the recommendations on what should be done to improve the skill gaps.

Table 3.2: Factors contributing to lack of utilization of ICT in learning of STEM subjects

Author (s)	**Factors**					
	Fear	*Gadgets*	*Internet*	*Skills*	*Electricity*	**Recommendations**

Ukwoma, Iwundu, & Iwundu, (2016)		√	√	√	√	
Wanjala (2016)	√	√	√	√	√	Equip schools with ICT gadgets, Acquire software, technical support, train teachers
Yalley (2017)				√		Training in ICT skills
Muhammad, S. *et al*. (2019)	√	√	√	√	√	Equip schools, technical support, train teachers
Mafuraga, M and Moremi, M. (2017)				√		Develop skills in teachers and learners
Alemu, B.M (2017)				√		Develop skills and relevant content
Alkahtani A., (2017)	√	√	√	√		Technical support, equipment school, internet support,
Zlotnikova I.K. *et al*,(2017)		√	√	√	√	Skill development, adaptation of technologies
Samuel, N., Onasanya, S.A, Yusuf, S.O, (2019)		√	√	√		Procure gadgets, train in digital skills, facilitate access, teachers understand students learning styles
Samuel et al., (2019)		√	√	√		Develop skills, ensure accessibility/connectivity

3.3 Students' skills capacity interventions on the use of ICT integration in the learning of STEM subjects

Presented in Table 3.3 is a summary of studies discussing skill capacity interventions on the use of ICT integration in learning STEM subjects.

Table 3.3: Skill Capacity Interventions

Author	**Capacity interventions**
Deaconu, (2017)	Avail ICT tools such internet for use in teaching/learning
Cuevas-salazar, Angulo-armenta, García-lópez, & Navarro-ibarra, (2016)	Use of ICTs to support learning
Sangra & Gonzalez-Sanmamed, (2010)	Use ICT in learning
Ruben, H.M et al.(2015)	Use of tablets and training in their use to maximize on their utilization in learning.
Basri, W. Alandejani, J.A& Almadani, F.M (2018)	ICT adaptation and use of e-materials influences academic performance. Training on use of gadgets
(Ormancı, U. (2020)	Adopt use of E- resources and other web based learning materials
Mollel MM & Mwantimwa, K, (2019)	Adopt use of e-resources by adopting access enhancing tools
Alontaga, J. V.Q. (2018)	Use e- resources in learning and research
Plangsorn, B. & Poopan, S. (2017)	Integration of e-books in the learning processes
Victoria, Batoon, David, & Morales, (2018)	Responsible use of e-materials, involve students in design of e- materials
Nyarkoa E A., Kariuki, M.G (2019)	Adopt e- materials, they make learning enjoyable
Samuel et al., (2019)	Train students and teachers' on the needed skills for use of digital media to facilitate teaching and learning
Pedaste, Leijen, Saks, De Jong, & Gillet, (2017)	Give students pedagogical skill and support to develop competencies in self-regulated learning

3.4 Students' perspective on Access of ICT in schools on learning of STEM Subjects

Table 3.4 presents students perspective on access of ICT in schools on learning STEM subjects. From the summary of the studies, it was observed that access of ICTs improves learning and hence impacting positively as far as performance is concerned.

Table 3.4: Access to ICT in learning of STEM subjects

Author	**Influence of ICT access**
Sabiri (2020)	ICT integration changes the traditional ways of learning, learners achieve more.
Ojo ,A. O and Adu, E.O (2018)	Advocate for ICT use in schools as it improves learning
Santos (2019)	Use of ICTs Influences performance
Siti et. al, (2020)	Using ICT are positive in T&L process
Yulong Li (2017)	m- learning(i-pad)based learning yielded positive results
Malia, H & Ramirez, A. Y (2018).	Teachers use of technology in class vital for performance
Nyarkoa E A., Kariuki, M.G (2019)	Adopt e- materials, they make learning enjoyable
Smith, (2010)	Tablets enhance reading and learning
Bergdahl, Nouri, & Fors, (2020)	Promotes engagement in learning
Alphonce & Mwantimwa, (2019)	Use of digital materials to promote learning
Algoufi,R.(2016)	Use of tablets promotes learning and new pedagogies
Mugo D.G. Njagi, K , Chemwei, B. (2017)	Students preferred to use the technologies over other existing instructional technologies.

3.5 Influence of availability of digital content in the cloud in the learning of STEM subjects

The summary of studies discussing availability of digital content in the cloud in learning of STEM is presented in Table 3.5. From the table it was found that availability of digital content in the cloud enables learners to access more information and it is quite engaging.

Table 3.5 influence of digital content in the cloud on learning of STEM subjects

Author	Influence
Mwakisole, Kissaka, Mtebe (2018)	Its advantageous to learning and access to information, it's feasible
Koutsopoulos & Papoutsis, (2017)	New paradigms in learning
Corbi, A & Burgos, D(2017)	Student engagement and satisfaction increased because of the easiness introduced by the container technology.

IV. Discussions

4.1. Pedagogical beliefs of students on use of ICT integration in learning of STEM subjects

Learning of STEM subjects has been challenging to students globally Mata, *et.al*(2012). This explains why there are very few students pursuing STEM careers at tertiary institutions yet the world today is technology driven. With all this information and knowledge, very few students are willing and confident to take STEM related career. Literature clearly shows that negative attitude is the main reason why learners perform poorly in STEM even when they have the ability to do so (Pale, 2016; Wekesa and Ongunya, 2016;Sarı,*et. al*., 2018; Mustafa, *et.al*. 2016;Han, 2017; Garneli, Giannakos, &Chorianopoulos, 2016). Eshun (2004) observes that attitude is a disposition towards a subject that has been acquired by an individual through his or her beliefs and experiences but which could be changed. Attitude is acquired over time depending on the environment the learner has been exposed to right from the home environment to the school environment where the teachers and peers play important roles in encouraging and discouraging the learners (*ibid*).

Researchers in factors for the poor performance in STEM (Ifeanacho, 2012; Iji and Harbour –Peters, 2005; and Ogbonna 2007; (Pedaste et al., 2017)De Jong, 2019;Han, 2017;Pale, 2016;Mustafa, 2016;Wekesa & Ongunya, 2016) point that the poor achievement in mathematics and sciences is largely attributed to inappropriate learning strategies which are mostly teacher centered and it's mostly from teachers perspective. According toGerrish (2017) children (and adults) fail in mathematics because they didn't study enough, and because, at least mathematics is often very poorly taught. It has also been observed that there is rote learning where students are subjected to memorizing formulae and sequencing of steps to be followed while solving mathematical problems. This leads to mathematics becoming boring, and, secondly, the intuition behind the math is usually ignored. There are also complaints about the subject matter, (Mustafa, *et.al*, 2016) that, the content is often not well-motivated with problems that appeal to kids. The learners sometimes do not comprehend the relevance of some of the content because it does not relate to real life experiences.

Related to content is also the way content is delivered. Researchers have argued in support of active learning methods for STEM (Ejiwale, 2013; Freeman, *et.al*, 2014;Wieman, 2014) for instance according to Freeman *et.al* (2014) average examination scores improved by about 6% in active learning sections, and that students in classes with traditional lecturing were 1.5 times more likely to fail than were students in classes with active learning. In the same study by Freeman *et.al*, 2014). Heterogeneity analyses indicated that across all the STEM disciplines, active learning increases scores on concept inventories more than on course examinations, and that active learning appears effective across all class sizes—although the greatest effects are in small classes. The arguments advanced are a clear indication that learning in STEM has issues which need to be addressed. Whereas there is a lot of literature from teachers' perspective, there is need to establish why there is dismal performance from a student perspective.

To address the poor performance in STEM, literature proposes a change in the teaching and learning strategies. The mostpreferred learning strategies were the learner centered pedagogies. The commonly favoured pedagogies were Problem Based Learning (PBL), Project Based Learning, student centered learning, and cooperative/collaborative learning, and inquiry based learning and hands on learning as amplified by(Su-Tin Yong*et. al*.,2018; Bishara & Wubbena,2018; Dean Cairns, & Areepattamannil, 2019; Mustafa, *et.al*., 2016; Han, 2017; Hanif *et.al*., 2019) Yildirim & Turk, 2018; Wekesa & Ongunya, 2016; Ohadugha, Chukwuemeka, & Babatunde, 2020)argue in favour of peer mediated learning in which learners take time to learn from one another with minimal or no teacher involvement. In the preferred pedagogies the learners are provided with tasks based on challenging questions or problems that involves the students problem-solving, decision-making, meaning-making, investigative skills and reflection(Wekesa and Ongunya, 2016; Thibaut, *et. al*., 2018),). According to Morrison *et.al*, (2015) the student centered pedagogieslearners develop competencies in problem solving, collaboration, inquiry, creativity and critical thinking as the learners are engaged in rigorous standard based curriculum and authentic and meaningful learning which involves real world challenges or problems. The goal of problem-based learning is for students to develop problem-solving skills by going through a realistic self-directed problem-solving and collaborative learning processes.

Owing to the challenges faced by learners in learning STEM subjects and the advantages of the learner centered pedagogies amplifies in the above studies, there is need to investigate further the reasons for poor performance in STEM and efficacy of the learner centered pedagogies advocated for in this review.

4.2 Skills gap on utilization of ICT in learning of STEM Subjects

As observed by (Noor-Ul-Amin, 2013; European Schoolnet, 2017;Mlambo *et al.,* 2020) utilization of ICT in instruction, enhances students' learning outcomes and that it makes science studies and careers more attractive for students. However, this is not the case in Kenya. The reasons for lack of utilization of technology in learning is related to non - availability of the technological gadgets which in effect brings about the skill gaps (Ukwoma, *et. al* 2016);Wanjala, 2016;Yalley, 2016; Ajegbelen, 2017; Muhammad et al., 2019; Alkahtani, 2017b; Zlotnikova, 2017b;Samuel et al., 2019; Ndiku, *et.al*, 2020).Most schools are not able to afford the gadgets and the utilization of the traditional technologies abounds in schools and the leaners therefore have no skills to use new technologies in learning.Basri, *et. al*., (2018) report the same in a study of universities in Saudi 'that a large number of students lack IT gadgets like smart phones and laptops. The main reasons for this are that they are expensive and there is a challenge of internet accessibility and electricity connectivity(Ukwoma et al., 2016; Wanjala, 2016; Ajegbelen, 2017; Muhammad *et al.*, 2019). They also argue that public servers, are costly and they are very slow in speed which makes it difficult for students to utilize ICT platforms on a regular basis.

According to (Akerlind and Trevitt, 1999; Wanjala, 2016; Tonui, *et.al.*, 2016; Alkahtani, 2017Orwenjo and Erastus, 2018) some students fail to use technology because of fear. The fear is usually associated with resistance to change as some of the learners would still wish to continue with what they are used to. Further, innovations have cost implications where investments in time and energy to acquire new skills is required and some students are not certain of payoff.

There are also issues of digital skills that, the digital skill set developed by the so-called "digital natives" is usually incomplete and has to be enhanced and refined by the school: The skills that young people develop by themselves with regard to technology do not necessarily help them to maximize learning opportunities (European schoolnet, 2016; Ukwoma, *et. al*., 2016; Wanjala, 2016; Yalley, 2017;Alemu, 2017; Ajegbelen, 2017; Muhammad, *et.al*, 2019; Alkahtani, 2017; Zlotnikova, 2016; Samuel, Onasanya and Yusuf, 2019).At stake as far as technology is concerned are individual differences and needs and the range of skills required to benefit from an educational use of technology. Such skill gaps need to be filled before the introduction of the digital technologies in instruction. As students come from different backgrounds, there is need to establish the skill gaps and fill them before introduction of digital devices in learning. The question is, do STEM and ICT curricula recognize that students may have very different starting points when entering secondary school and are they appropriate for the cognitive and linguistic level of all learners(Barrett and Tikly, 2018).

The literature review thusconfirmed the above argument about the factors contributing to lack of utilization of ICT in schools; fear, lack of gadgets, lack of internet connectivity, shortage of ICT skills, and lack of electricity connectivity. Thus, for ease of utilization of ICT in schools, there is need to; equip schools with ICT gadgets, train staff and students in ICT skills, give technical support to learners, acquire the relevant software, adopt relevant technologies(Ukwoma, *et. al*., 2016; Wanjala, 2016; Yalley, 2017;Alemu, 2017; Ajegbelen, 2017; Muhammad, *et.al*, 2019; Alkahtani, 2017; Zlotnikova, 2016; Samuel, Onasanya and Yusuf, 2019Oluwole and Mojapelo, 2020). However, whereas in the opinion of these authors' recommendations it's clear the action to take, there is need for an empirical study to get the views of the learners on the skills gaps and the contributing factors to these skill gaps.

4.3 Plausible Capacity Interventions on the use of ICT Integration in the learning of STEM subjects

Massive investments in Information and Communication Technology in schools have not yet resulted in the hoped for transformation of educational practices, probably because there is more focus on hardware and connectivity instead of increasing teachers' and students' ICT skills, reforming pedagogies and producing appropriate software and courseware(OECD, 2016), yet literature shows that there is a growing emphasis on the use of technology to support deeper learning approaches for engaging students in 21st century skills of 'critical thinking, problem solving, collaboration and self-directed learning' (OECD, 2015). This is driven by trends towards innovative learning approaches for 'project, competency-and challenge-based learning' and school structures 'that enable students to move from one learning activity to another more organically, removing the limitations of bell schedules(*ibid*).

Literature review by Hooker (2017) reports of success stories of technology use for deeper learning such as the European Union (EU) Go-Lab project and online portal offering innovative, interactive, collaborative and context-aware tools and functionalities that provides a student-centered interface to promote contextualized and adaptable learning experiences. Hooker (2017) further cites Dede (2014) who reports a case

in the USA on the use of the EcoMUVE (multi-user virtual environment ecosystem) middle grade curriculum initiative engaging students to assume the role of scientists, investigating research questions by exploring the project virtual environment and collecting and analyzing data from a variety of sources over time.

According to Sangra & Gonzalez-Sanmamed (2010) , use of ICT favours several processes related to teaching and learning in particular; those involving attention, perception, responding mechanisms, application of learning and understanding. The authors further argue that schoolsshould modernize the technological tools and change the teaching models especially the teacher's role, regarding classroom organization, the teaching and learning processes and the interaction mechanisms. This explains whyMocanu and Deaconu (2017)and other authors argue in support of ICT integration in teaching and learning. Critical in this is to ensure all the students have the same skill base in utilizing ICTs in learning to maximize on the learning processes using ICT. As the argument is advanced in(OECD, 2015) there is need for training in order to provide educators with learning environments that support 21st-century pedagogies and provide children with the 21st-century skills they need to succeed in the forthcoming generations. Such skills can be obtained with enabled access to e-materials (Nyarkoa & Kariuki, 2019)as mobile technology has made internet access so easy and handy to influence certain preferences and learners access of resources for e-Learning such as computers, smartphones, the internet, and electricity are the fundamental building block for successful eLearning implementation. Coşkun, (2017) arguing in support of internet in learning of English, recommends internet activities such as chat rooms, e-mediated tandem learning, listening logs, digital media, and digital games use of Internet tools instant messaging, discussion boards, interactive blogs, online forums, Social networks (e.g., Facebook, Second Life), and voice-chat programs (e.g., Skype, iChat).

Against the above arguments, the review identified the need to avail and adopt utilization and integration and utilizationof e- material such as books and the internet in teaching and learning, use of tablets and training in their use to maximize on their utilization in learning and give students pedagogical skill,support the use of e-modules and need for skills to access them and support to develop competencies in self-regulated learning(Ruben,*et.al*.,2015;Sangrà, & Sanmamed, 2016;Plangsorn & Poopan, 2017; Mocanu,& Deaconu, 2017;Cuevas-Salazar, Angulo-Armenta, García-López, & Navarro-Ibarra, 2016; Basri, Alandejani, & Almadani, 2018; Alontaga, 2018; Mollel & Mwantimwa, 2019; Dawkins and Gavigan, 2019; Nyarkoa & Kariuki, 2019; Samuel, Onasanya, Yusuf, 2019;Ormanci, 2020).

4.4 Students' Perspective on access to ICT in teaching of STEM subjects

Barakabitze et al., (2019)observe that ICT integration in the classroom, enables students to engage themselves in interactive tasks with a wider range of information and knowledge during their learning and that ICT skill and knowledge play a great role in ICT integration in the education system. This resonates well with the argument that the future of ICT in Africa hinges on embracing new technologies that will; improve motivation and enhance student engagement, promote self-regulated and collaborated learning, enforce challenge-driven and human-centered learning(Noor-Ul-Amin, 2013). According to (Nyarkoa & Kariuki, 2019;Otieno, 2019)using computers in learning has many benefits such as; helping learners remember easily what they have learnt, understand easily, concentrate more on what they are learning, working better with other students, developing independence in their learning, improve the class atmosphere, make difficult concepts easy to understand, make learning fun, help learners recall what they had learnt, make them more active and engaged in learning. Otieno (2019) further reports learners' interest and performance in the subjects where ICT is being used had improved and also observes learners have a strong preference for lesson where ICT is integrated to conventional lessons an argument also held by Mugo, Njagi, & Chemwei, (2017).

Basri et al., (2018) in their study on utilization of ICT in Saudia universities reported and concluded that Information Communication Technology (ICT) is among the latest innovations that has revolutionized various operations in the world and that it is important in the field of education since it has created such platforms and opportunities that have facilitated to some extent the acquisition of knowledge. In the study students view ICT as a component of their study program where majority of the respondents value ICT, and each of them feels that they should have ICT gadgets to be able to adopt ICT more closely. They further argue that besides searching for information from the internet, the university students make use of ICT for communication and social connections with friends and relatives. This explains why it is a major booster to academic performance of the students in the university. The same students use ICT to facilitate discussions and feedback on academic matters from teachers, seniors, and colleagues (*ibid*).

From their study also, Basri *et al*., (2018) found that students who score higher grades in GPA are more interested in ICT than their colleagues who score lower grades and that brighter students are therefore more likely to embrace ICT. It was also revealed in the same study that social science students readily adopt ICT more than their other counterparts. An interesting finding of this study was that there has been an increased use of ICT particularly to search for information related to studies. Adoption of ICT therefore is very high among

the university students as majority (more than two-thirds) use ICT at least for two hours in a day. The findings of this study point to the need to offer full support to students' access of ICT owing to its potential to improve their academic performance and that majority of the students who use ICT for academic purposes are also involved in the use of social media which consumes a lot of their time. Despite the small bit of students spending more time on social media, the benefits of ICT in learning cannot be overemphasized. From this argument, the use of ICTs in education and student outcomes, including retention and learning achievement, directly changes the nature of teaching and learning, delivery mechanisms for teaching and learning, and the foundational ICT-based pedagogy that matters to current and future African students.

Review of literature on the extent to which access to ICT in schools influences the students' perspective on learning of STEM subjects revealed that, it enable self-directed computer-supported collaborative inquiry-based learning(Pedaste et al., 2017). To this end along with availing the gadgets, students need to be supported though training to access e-materials. Arguing in favour of ICT access and utilization Gyamfi (2017) acknowledges ICT as a pre-requisite for teaching and learning in the 21st century. Acknowledging the value for ICT in learning,Sabiri (2020) observes that, ICT integration changes the traditional ways of teaching and learning. It motivates teachers and learners to adapt technology and modify teaching material and strategies to meet the needs of the day and learners achieve more in the learning outcomes (Francis, 2017). Ojo and Adu (2018) in their study observed that ICT gadgets were used in education in South Africa and owing to importance of ICT utilization in learning recommend funding ICTs in schools through training and re-training of teachers and exposure of stakeholders to the relevance of the pedagogy relating to the use of ICTs for teaching and learning.

Reporting on the utilization of ICTs in learning, English, students in Vietnam,Ngo & Eichelberger, (2006)noted that ICTs were beneficial in augmenting receptive English over expressive English skills.Santos, (2019) in their studyaver that ICT literacy is a determining factor in school performance of students of the 3rd cycle of basic education and secondary education in the district of Vila Real, Portugal. It was also verified that the use of internet to study is a preponderant factor for school performance. Use of ICT is positive in the Teaching &Learning process (Siti, *et.al,* 2020)propose to increase the effective use of ICT among adolescents among the urban poor. Malia, & Ramirez (2018) in a study to measure students' attitude towards teacher use of technology, the students from the survey were reported to believe that teacher use of technology within the classroom is vital for their overall performance in life and indicated that they thrive when teachers use technology in group work.

Smith, (2010) in a study that explored the use of tablets to enhance English reading among learners in Grade 5 from selected primary schools in Atteridgeville the findings reveal that learners using tablets have an advantage, because modern digital natives enjoy the use of technology to communicate and learn, which enhances their reading and learning and that tablets provide learners with the opportunity to experience technology physically and independently. Bergdahl, Nouri, & Fors(2020), report of a significant correlations between students' digital skills and engagement in Technology Enhanced Learning (TEL). This indicated that possession of high levels of digital skill is related to engagement in TEL.

4.5 Availability of digital content in the cloud on the use of ICT integration in the learning of STEM subjects

Availability of digital content repositories and cloud storage of information has brought a revolution in learning in that materials are not only more accessible but also available to a wide range of users in different modes. This not only enable students to self-instruct and get more knowledge but also enables them to discover and innovate, allows education to be holistic as well as bring into teaching and learning the necessary dynamic, interactive and multimedia tools. That is why theUS Department of Education (2017) observes that Technology-enabled learning allows learners to tap resources and expertise anywhere in the world, starting with their own communities. This enables students to take courses online, student can access high-quality online mentoring and advise on programs where resources or geography present challenges to obtaining sufficient face-to-face mentoring, students in a remote geographic area studying local phenomena can collaborate with peers doing similar work anywhere in the world, school with minimal equipment can offer course in collaboration with schools which are better endowed, students engaged in creative writing, music, or media production can publish their work to a broad global audience regardless of where they go to school, and that technology allows less experienced learners to access and participate in specialized communities of practice, graduating to more complex activities and deeper participation as they gain the experience needed to become expert members of the community.

Amplifying the advantages of technology aided learning (Davis *et.al.* 2013; US Department of Education, 2017), note that, technology can enable personalized learning or experiences that are more engaging and relevant, help organize learning around real-world challenges and project-based learning, help learning move beyond the classroom and take advantage of learning opportunities available in museums, libraries, and other out-of-school settings, help learners pursue passions and personal interests, can help close the digital

divide and make transformative learning opportunities available to all learners. It also enable one to get access to abundance of information. This resonates with the arguments by (Savec and Slovenia, 2019) that digital learning is more engaging, develops accountability in students and that there is ease of sharing of knowledge. Due to the wide set of benefits digital learning gives to students, it has become quite popular and appreciated among students all over the world. Further, Koutsopoulos& Papoutsis (2016) argue that cloud computing brings with it cost cutting, flexibility, effectiveness, sharing, real time access and reduces the risk of obsolescence. The authors further argue that in cloud computing learning should be focused on four not the three basic object competences; should be tailored to the Needs of Individuals; should be based on a Holistic New Vision; should be active and Connected to Real Life should be towards open, flexible and networked relationships; and thus with cloud computing online, distance, hybrid, flipped, non- formal, learning should be strengthened and that network learning should determine the design of a curriculum. Cloud computing brings with it new methods of teaching such as collaborative teaching collective teaching, personalized teaching, parents teaching, real-time assessment and predictive analysis in teachingand that the teacher's role changes to that of a guide, advisor and referee(*ibid*).

The predisposing factors to utilization of technology in instruction are; continued improvement of Information and Communication Technologies (ICT) infrastructure, penetration of mobile phones, the declining cost of Internet, declining cost of mobile devices such as smartphones and tablets (Mwakisole*et al.*, 2018). In their study; Exploring Patterns in Student Dialogue While Using a Digital Platform Designed to Support Online Inquiry (Murphy, Coiro, and Kiili, 2019) found prompts and features of digital platforms can help students engage in productive dialogue. With this, e- learning can be instituted because it potentially improve the quality of teaching and learningin secondary schools, teachers can share and exchange information and knowledgewith their students. However, very few schools have managed to implement eLearning systems due to costs as well as lack of reliable ICT infrastructure in school premises. The majority of existing eLearning initiatives such as Halostudy, Shuledirect have been implemented by NGOs or mobile firms (Mwakisole*et al.*, 2018).Following their conclusion that cloud computing can shape the way eLearning is implemented in secondary schools in developing countries and that this is feasible, that students can continue to access learning materials via the Internet, this provides a strong base for implementing eLearning in the cloud.

V. Conclusion

The literature review identified some of issues in the learning STEM subjects from a students' perspective where the factors for poor performance in STEM are amplified and the preferred pedagogies to improve the performance.

There is evidence that utilization of ICTs in learning STEM subjects is real and it is majorly contributed to by lack of availability of gadgets, connectivity and lack of information. Lack of digital content and access of it is still a challenge and that to improve on the skills there is need toavail and adopt utilization and integration of e- material in learning and availability of e materials in the cloud.

VI. Recommendations

From the study results and the conclusions thereof, learner perspectives in learning STEM subjects are minimal and they are really understood and sought for. There is therefore need to empirically establish the influence of utilization of Technology in learning and utilization of the Digital information in the cloud for improved learning.

Further studies are also recommended to explore the digital library characteristics and outcomes of utilizing the same learning from a students' perspective.

Owing to challenges of connectivity and availability of gadgets there is need to establish intervention requirements in provisions of these gadgets to facilitate access to the digital content by the learners.

VII. Limitations

The review acknowledges the literature reviewed from different sources may not have had all the information and that the literature search and review is limited by its availability and human error in the search process. Despite this the findings, discussions and conclusions thereof are a reflection of experiences in the learning institutions as reported through some empirical studies reported by stakeholders, students included.It is hoped the sources provide useful information and an eye opener for future interventions in improving learning in STEM.

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