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Virtual Learning Environment in STEAM Education

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A R T I C L E I N F O

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A B S T R A C

This paper discusses the use of Virtual Learning Environments (VLEs) in STEAM (Science, Technology, Engineering, Arts, and Mathematics) education. The integration of technology in education has become increasingly important, and VLEs are becoming more popular as a means of delivering educational content. VLEs are online platforms that provide interactive and collaborative learning experiences through the use of multimedia, simulations, and virtual reality. This paper explores the potential benefits of using VLEs in STEAM education, such as increased engagement, enhanced problem-solving skills, and improved student outcomes. Additionally, this paper highlights the conceptual, the theoretical and the empirical evidences of virtual learning environments in STEAM education. The challenges associated with the implementation of VLEs in STEAM education, such as the need for adequate teacher training and support, and the potential for technological problems. Finally, this paper provides suggestions for the successful integration of VLEs in STEAM education, including the importance of selecting appropriate software, offering technical support, and providing opportunities for collaboration and feedback.

1. Introduction

The outcomes of teaching and learning environment are the most paramount factors that justify the efficacy and effectiveness of the inputs into the teaching-learning environment. The teaching-learning environment becomes more paramount especially in most often dreaded subjects like science, technology, engineering and mathematics. Evidence in research signals learners' disheartening and precarious low achievement and aversive attitude towards science, technology, engineering, arts and mathematics as non-integrated, compactmentalised subjects (Olagunju&Adesina, 2017; Obanya, 2021; Okebukola, 2022; Gambari, 2021). Although there is a recent surge in secondary school students' performance in external examinations like West African Senior Secondary Certificate Examination (2017-2023) compared to the preceding years, this could not be justified by the appalling low achievement of these students while in tertiary institutions as evident in their low 21st century skills (skills like critical thinking, creativity, collaboration, communication, citizenship skills, self-regulation, knowledge construction, problem-solving, time management, digital literacy etc), low employability and entrepreneurial capacity (Obanya, 2021; Adesina et al., 2023).

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The cruise to sync the four subjects, Science, Technology, Engineering and Mathematics as STEM construct produces students that are bookish with head knowledge without corresponding capacity or capability to solve societal problems (Zhan et al., 2023; The British International School of STEAM, 2023). The STEM construct lacks ability, creativity, critical thinking along problem-solving ability that are expedient in the ever changing society. Thus, the need to add arts, socio-cultural subjects like creative arts, music, social studies, civic studies, literature etc into STEM to fashion out another construct known as STEAM education.

STEAM education in an interdisciplinary kind of education which amalgamate the cross-cutting concepts in science, technology, engineering, arts and mathematics to form a unified, holistic construct to impacts not only the scientific concepts, knowledge and theories, the technological principles, the engineering ideas, the mathematics constructs but also the socio-cultural dimension of STEM with environmental issues and challenges like matter and materials, resources allocation and utilization, energy development, governance, environmental issues, global warming, climate change and other socio-cultural concerns in focus. STEAM education when appropriately taught has the propensity and tendency of instilling the 21st century skills of critical thinking, creativity, collaboration, communication, citizenship skills, knowledge construction, self-regulation, time management, problem-solving, digital literacy and many other positive skills in the recipients if appropriately taught (Kartini et al., 2023; Mariana &Kristanto, 2023).

Over the years, research findings have repeatedly reported the adverse effects of the conventional instructional strategies as a major contributor to low learners' learning outcomes in unamalgamated science, technology, engineering, arts and mathematics (Adebiyi, 2019; Obanya, 2021; Olagunju&Ige, 2013; Olagunju&Adesina, 2017; Okebukola, 2021, 2022). The conventional instructional approach is transmissional and didactic (Ehindero, 2014), non-interest stimulating and poor attention grabbers (Adebiyi, 2019), non-interest sustaining (Obanya, 2021), non-hands-on-mind-on (Olagunju&Ige, 2013; Olagunju&Adesina, 2017). The conventional instructional strategies that engender rote learning, memorization and regurgitation of facts, concepts, hypotheses, theories, laws and principles of science, technology, engineering, arts and mathematics without a corresponding impacts on the environmental sustainability (Dahiru&Alhassan, 2023; Adesina, 2022; Gambari, 2021). The conventional strategies are not aligned with the Next Generation Science Standard (NGSS) of National Science Teaching Association (NSTA) in America that recommended science and allied subjects teaching and learning with technology and reflective thinking (NSTA, 2012; 2015; 2020).

The cruise to align STEAM education with the NGSS calls for the integration of virtual learning environment in STEAM teaching and learning where the learners of STEAM education are exposed to virtual learning environment (VLE), the interactivity and engagement becomes heuristic, stimulating, interest sustaining, hands-on-mind-on approach, creative, critical in thought, explorational, collaborative, communicative, self-regulating, problem-solving, digital and adept time management (Adesina et al., 2023; Chisunum&Idialu, 2023; Niu et al., 2023; OECD, 2023; Okebukola, 2022). The 2020 Corona Virus pandemic (Covid-19) saga that shut all social, economic, political and other institutions including the educational industry compelled a shift in instructional paradigm from the conventional to the virtual learning environment.

2. STEM: A Precursor for STEAM Education

STEAM is an educational paradigm that allows the students to create meaning for themselves and others in science, technology, engineering, arts and mathematics amalgam. STEM construct precedes theSTEAM education with the deficiency of arts construct in STEM which invariably impairs the smooth application of knowledge, ideas and acquired skills in STEM education to solve societal challenges. STEM integrated with arts produces STEAM. STEAM education is more comprehensive, more involving, more socio-cultural oriented and more 21st century skills laiden for overall individual development (Niu et al., 2023;). It aims to guide learners to use interdisciplinary knowledge to solve practical problems. STEAM acronyms strand for Science, Technology, Engineering, Arts and Mathematics.STEAM Education is an approach to teaching and learning that combines science, technology, engineering, the arts, and math to guide student inquiry, discussion, and problem-solving. It emphasizes practical and project-based learning that students can touch, feel, hear, see, smell, build, and draw themselves. STEAM Education helps the students to develop the capacity to take thoughtful risks, engage in meaningful learning activities, become resilient problem solvers, embrace, appreciate collaboration and work through the creative processes.STEAM education focuses on the connection between knowledge of different subjects and guides learners to use interdisciplinary thinking to learn and solve real problems.

The five strands of STEAM defined as follows: Science is a systematic study of the nature and behavior of the material and physical universe, based on observation, experimentation, and measurement. Sulai and Kaluri (2018) defined science as an intellectual activity carried out by humans to discover ways in which information can be organized to benefit the human race. Science education aims to bring about more scientifically literate citizens and develop more manpower to meet world advancements in science and technology. Scientific knowledge is gained through observation, measurement and experimentation, which leads to development of principles and theories from scientific activities (Ajayi&Ogbegba, 2017).

Technology is the branch of knowledge that deals with the application of scientific knowledge to the practical aims of human life or to the change and manipulation of the human environment. It involves the creation and use of technical means and their interrelation with life, society, and the environment (Suleiman et al., 2018). Engineering is a discipline dedicated to problem-solving, using natural science, mathematics, and the engineering design process to solve technical problems, increase efficiency and productivity, and improve systems (Hammack& Anderson, 2022)..

Arts is a diverse range of human activity that involves creative or imaginative talent expressed through technical proficiency, beauty, emotional power, or conceptual ideas. There are many divisions/categories in arts, such as language arts, fine arts, and physical arts (Georgette, 2008; Vasari, 2007). Mathematics is a potent way of building mental discipline and encouraging logical reasoning and mental rigor. It is essential in various fields of human endeavor, including commerce, farming, environmental control, medicine, engineering, administration, budgeting, bill payments, and problem-solving (Abe &Gbenro, 2014; Yadav, 2019). Mathematics is seen as a basic analytical tool for different theories and postulations in different fields, especially science-related fields (Amao, 2015). STEAM education emphasizes both liberal arts and sciences, focusing on cultivating science and engineering literacy. It guides learners to use interdisciplinary thinking to learn and solve real problems.

The integration of interdisciplinary knowledge, STEAM education creates a situation for learners to creatively solve practical problems by using multidisciplinary knowledge. Its goal is to cultivate learners' basic literacy in science and innovation. Compared with the traditional subject education, STEAM education truly breaks the limitation and lag of the traditional subject education concept by cultivating the comprehensive application ability of knowledge under the guidance of interdisciplinary thinking, and realizes the organic integration of science, technology, engineering, art, mathematics and other disciplines (Wu, 2020). Project-based learning and problem-based learning are the most common STEAM teaching methods. The STEAM education philosophy emphasizes that learners should carry out practical activities to complete projects closely related to real life and solve practical problems in reality. In this process, learners can master interdisciplinary and multi-disciplinary knowledge, and cultivate their comprehensive ability to explore different aspects of the real world and practical operation ability by transforming the knowledge they learn and the project process.

3. Virtual Learning Environment

A virtual learning environment is a web-based virtual reality created by human beings with the use of computer software, sensor technology, and multidisciplinary knowledge in exploring nature throughscientific processes for scientific understanding of nature and simulation (Chen et al., 2020). Virtual learning environments are also known as learning management systems, electronic educational technology, e-learning, online learning or learning platforms. Virtual learning environments are digital platforms that facilitate the delivery of educational resources and interaction between students and instructors in an online environment.Numerous virtual learning environments canbe accessed through the internet via computers.

There are three ways to learn in a virtual environment. These are synchronous where students are asked to attend live-streamed lectures, presentations, and discussions on certain issues or topics. The students can ask questions via webcam, microphone or live chats for more enhancing learning experiences. The asynchronous virtual learning is characterised by pre-recorded lectures or presentations that can be watched at the students' time and space. Aside, the video or audio files with lecture notes, the quizzes are attached to monitor the learning of the students. The teacher or instructor attends to students' queries via emails with each other or text chats. It provides a forum for both past and current students to communicate with each other for details discussions on the lectures or presentations. Hybrid virtual learning employs the characteristics of both the asynchronous and synchronous.

Virtual learning environments are characteristics with content management (e. g. Moodle), communication and collaboration (e. g. Blackboard Collaboration) assessment and quizzes (e. g. Canvas), discussion forum (e. g. Google Classroom), learning analytics (Brightspace by Desire21Learn, D21), virtual labs and simulations (e. g. Labster, Lab Xchange), mobile learning (e. g. Edmodo), content personalisation (e. g. Schoology), accessibility and inclusivity (e. g. Desire21Learn, D21 Brightspace) and open source option (e,g. Sakai). These diverse range of features that virtual learning environments provide, enhance the online learning experiences, making education more accessible and flexible for learners and instructors (McPheat, 2022).

Virtual learning allowslearners to access coursework from anywhere, at any time and at their space thereby making the learning more convenient for the learners.Online courses are associated with higher retention and graduation rates,offers greater opportunities for postgraduate study, better attendance at classes, increased access to online materials, better use of organisational infrastructures and cost savings.Virtual completion of courses can also increase students' digital aptitude, and preparation of students for life in the digital workforce. Teacher can also conduct more frequent assessments to ensure students are on track (Laal&Ghodsi, 2012; Al Rawashdeh et al., 2021; UCapture, 2023).

4. Learning Theories that Guide the Use of Virtual Learning Environment in STEAM

Major learning theories upon which integration virtual learning in STEAM for interdisciplinary content, creative and critical thinking, inclusive and lifelong learning skills include behaviourism, constructivism, constructionism, connectivism, technology acceptance theory, self-determination theory and activity theory. The behaviourism is a theory of behavioural pattern in humans and other animals in response to certain stimuli. In teaching and learning, behaviourism is a process of conditioning students properly react to stimuli (Skinner, 1939 in Olagunju&Adesina, 2017). Cognitivism believes that learner actively construct in the mind by their interaction with the learning environment. It is concerned with how information is processed, stored, retrieved and applied. Constructionism is a theory in which students construct artefacts in outside world that support and reflect the learners' internal construction of information.

Connectivism emphasises the role of networks and connections learning. The theory highlights the importance of leveraging digital technologies to create meaningful connections and facilitate knowledge sharing.Technology acceptance theory explores users accepts and use technology. In virtual learning, this theory guides the design and implementation of user-friendly and effective educational technologies by considering factors such as ease of usage, quality and usefulness of knowledge contents and technology. Self-determination theory focuses on the learner's intrinsic motivation and autonomy. The theory suggests that provision of learners' choices, self-efficacy and opportunities for competence can enhance learners' engagement and motivation in virtual learning. Activity theory views learning as a dynamic process within the social content. It provides developmental ways that conceptual frameworks and technologies, practical actions in the world, individuals, and social institutions shape and are shaped by one another in the learning process (Engestrom, 1987; Ottenbreit-Leftwich&Kimmon, 2020; Spero, 2023).

5. Conceptual Frameworks for Virtual Learning Environment in STEAM Education

There are some of conceptual frameworks that show the variables of virtual learning environments that can be used in research forsuccessful implementations and to minimize challenges that may be associated with virtual learning environments in STEAM.

5.1 Eight-Component Framework

Khan (2001) proposed the first virtual framework called the eight-component framework. This framework consists of eight dimensions which contribute to the success of virtual learning. These are institutional, pedagogical, technological design, evaluation, management, resource support and ethical dimensions. The institutional dimension deals with all the affairs related to administrative, academic and even the student's services. The pedagogical dimension is related to the teaching and learning process, while the technological dimension deals with the issues of technology in an institution/organisation. The other dimensions are related to virtual learning environments which are interface design, assessment and evaluation, management and maintenance of the systems, the support for online version and the ethical which is the social and cultural issues.

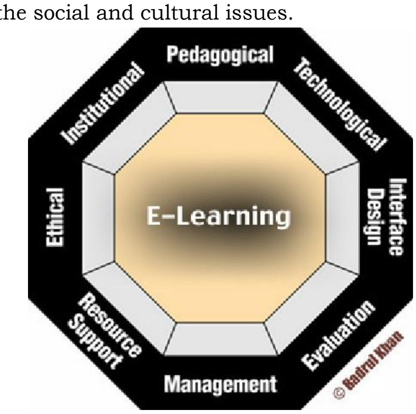

Figure 1. Khan (2001) Eight-Component Framework on Virtual Learning Achievements

From Khan (2001), for an effective virtual learning environment to take place there is need for mutual interactions among the institutional, technological, interface design, evaluation, management, resource supports and proper ethical consideration that will enhance, enable, enrich and empower the e-learning environment.

Sun et al (2008) proposed a virtual learning integrated model indicated in Figure 2, comprises of six dimensions, and thirteen variables within the identified dimensions for learners' satisfaction in the usage of virtual learning. The six dimensions of the model are learner, instruction, course, technology, design and environment dimensions. The learners' attitude, computer anxiety and internet self-efficacy are vital attribute to be considered in learner's satisfaction of virtual learning. Other variables as relate to the integrated dimensions arelearner's the instructor response timeline instructor attitude toward virtual learning,course flexibility and its quality, technology and internet quality, perceive usefulness and ease of the learning design, diversity in assessment of learner response and perceived learner interaction with others learners. These variables have potential influence on the satisfaction derive from virtual learning in STEAM.

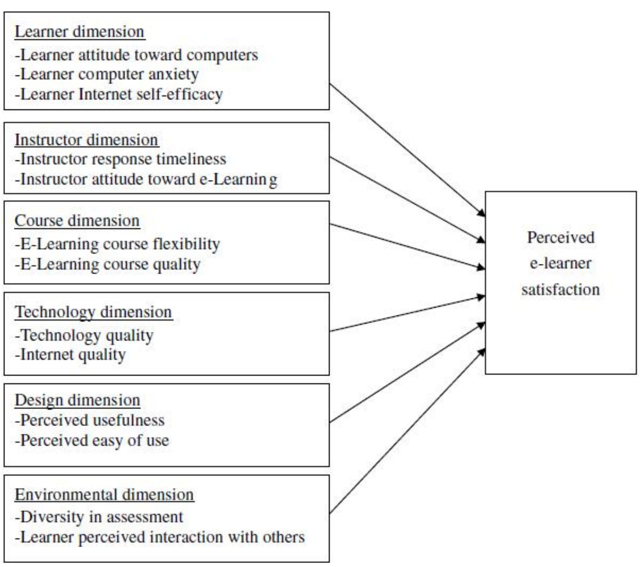

Figure 2: Sun et al (2008) Integrated Model of Virtual Learning Learner Satisfaction

From figure 2, the perceived e-learner's satisfaction is determined by the learner dimension (learner attitude towards technology, learner technology anxiety, learner intended self-efficacy), instructor dimension (instructor response timeliness, instructor attitude towards virtual learning environment), the course dimension (e-learning course flexibility, e-learning course quality), technology dimension (technology quality, internet quality), design dimension (perceived usefulness, perceived ease of use) and the environmental dimension (diversity in assessment, learners perceived interaction with others).

Davis (1989) proposed a technology acceptance model (TAM) in Figure 3. It is an information system theory that models how users accept and use technology. In the environmental dimension, the proper feedback mechanism through the learning environment and activities is important to virtual learners.

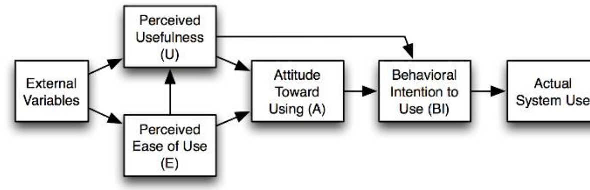

Figure 3: Davis (1989) Technology Acceptance Model

Figure 3 revealed that for the virtual learning environment to take place there ought to be technology acceptance which is predicated by perceived ease of use and perceived usefulness and that the perceptions is determined by individuals attitude towards using the technology, the behavioural intention to use the technology and the actual system use (virtual learning environment).

5.2 LearnCube Conceptual Framework

LearnCube is the one of the most current conceptual framework for virtual learning. The framework was proposed by Haw et al (2015) for the implementation of virtual learning in secondary schools as indicated in Figure 6.

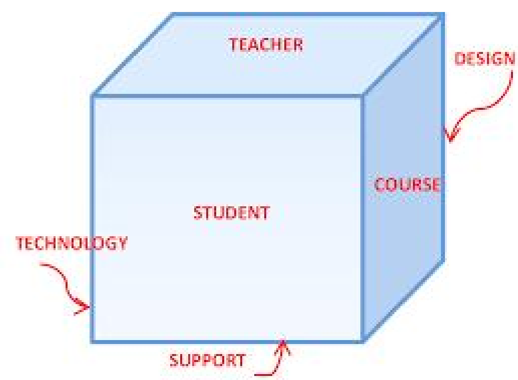

Figure 4: Haw et al LearnCube for Virtual Learning Implementation

The beauty of LearnCube framework in cube modelling was that the conceptual social factors (CSFs) in multi-dimensions. The model consists of six main dimensions with eighteen variables within the dimensions. The dimensions are student, teacher, technology, course, content, design and support. The model supports decision making by allowing the user to slice and dice a dimension for selection of a specific dimension of interest, e. g. teache, and has the ability to analyis inter-relatio between two or more dimensions, e.g. student and teacher.

The variables assocaited with the six dimensions of the LearnCube are describe in Table 1.

Table 1.Attributes of the Dimensions of Learn Cube

Dimension	Attributes
Student	Student motivation Student attitude Peer influence
Teacher	Teacher attitude Peer influence Pedagogy
Course	Material selection Material presentation Material assessment
Design	Perceive ease of use

	Perceive usefulness Quality of content
Technology	Quality of internet access YouTube Online forum
Support	Management support Government support Resources

From Table 1, the students' motivation, attitude and peer influence, the teacher attitude, peer influence and pedagogy, the course selection, presentation, and assessment, the design perceived ease of use, usefulness, quality of content, the technology quality of internet access, YouTube online forum, and the support management, government support and resources availability all interact together to determine the quality and efficiency of virtual learning environment in STEAM education.

6. Empirical Reviews of Virtual Learning Environment in STEAM Education

Maddox (2015) researched into adapting to a virtual learning environment. found that there are challenges in adapting VLE, however, VLE engaged and enhanced students learning than the conventional environment. Madathil et al. (2017) in an empirical study investigating the effectiveness of integrating virtual reality-based case studies into an online asynchronous learning environment found that students' perception of learning including ease of comprehension, ease of memorization, usability, and active learning revealed significant improvements with the virtual reality (VR) and that VR improved students learning. Ajit et al. (2020) in a systematic review of augmented reality (AR) in STEM education found the most reported benefit of AR is that it stimulates learning achievement.

Hu et al. (2023) studied the construction and application of VR / AR-based STEAM curriculum system in primary and middle schools under big data background found that through the virtual reality technology, STEAM education can reproduce the natural phenomena or the changing process of things that cannot be observed in real life, provide learners with vivid and realistic

sensuous learning materials, and make the abstract concept theory intuitive and visual, convenient for learners. Siregar et al. (2023) determined the impact of mobile technology on an integrated STEAM project delivered via mobile technology on the reasoning ability of elementary school students. The results indicated development of learning models that could improve reasoning learners' reasoning abilities to accelerate the recovery of quality education during challenging times such as a pandemic. Hite et al. (2024) researched into modeling secondary students' active learning in a virtual learning environment through generated questions the findings revealed a significance in sixth graders' abilities to progress from active processes to the higher and more sophisticated learning processes and the presence of interactive processes suggests that VLEs are immersive, interactive, and able to foster robust science learning.

Schauer et al. (2022) compared virtual and in-person learning whenin an identical experimentwas performed by the students. Results indicated that neither learning formats presented an advantage over the other when it came to the quality of designs produced during the intervention. However, the participants across all experimental groups reported an increase in self-efficacy after the intervention, with improved performance on quiz-type questions. The novelty and variety of the designs produced by the in-person experimental groups were significantly lower than that of the virtual experimental groups. Akgun and Atici (2022) observed that immersive virtual reality environment had many positive effects on students' cognitive, affect, and psychomotor skills and created a perception of reality and sense of presence in students, facilitates learning environment and make many contributions to learning. In addition. it was determined that there were technical and health problems during the usage of the environments

Some other reported barriers and challenges of virtual learning environments include limited interpersonal contacts and isolations from peers, financial problems, lack of adequate knowledge about learning virtual learning environment, difficulties in assessment of progress in different domains, inadequate skills of technology and experiences in virtual learning, content ambiguity, quality of resources, pedagogical processes and institutions' support, organisational and structural factors (Parte&Herrador-Alcaide, 2021; Ibraheem et al., 2022; Stecula&Woliniak, 2022).

7. Conclusion

In conclusion, the Virtual Learning Environment (VLE) provides an innovative and effective approach to STEAM education. With the integration of technology and immersive learning experiences, students are able to engage with complex concepts, develop critical thinking, creativity and problem-solving skills. The VLE also offers flexibility and accessibility, allowing students to learn at their own pace and from any location. Moreover, the VLE promotes collaboration and communication among students and teachers, creating a dynamic learning community. As technology continues to advance and shape our world, it is essential that we incorporate it into education, and the VLE is a promising solution for STEAM education.

8. Suggestions for Enhanced Virtual Learning Environment in STEAM Education

Here are some suggestions for the article titled "Virtual Learning Environment in STEAM Education":

1. Institutional managers should organize in seminars, workshops, conferences, symposia to provide copious examples of successful VLE implementation in STEAM education. STEAM education teachers would benefit from seeing real-world applications of the VLE in different educational settings.
2. Government and Non-Governmental Organisations (NGOs) should refurbish educational institutions with virtual learning infrastructures like technological tools, internet facilities, steady power supply to facilitate the solid integration of VLE in STEAM education.
3. Science, Technology, Engineering, Arts and Mathematics teachers to brace up themselves to explore the potential for the VLE to support differentiated instruction in STEAM education. The VLE can be used to provide personalized learning experiences that meet the needs of individual students with varying abilities and learning styles.
4. Government and Ministries of Education should arrange teacher training and professional STEAM teachers' development in effectively using the VLE in STEAM education. Teachers need to be trained in how to use the VLE and how to design effective learning experiences that leverage its capabilities.
5. Government and Non-Governmental Organizations (NGOs) should address the need for equitable access to the VLE

in STEAM education. Not all students may have access to technology or the internet at home, and this could create disparities in learning opportunities. Ways to address this issue should be explored.

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