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GRAVITATING TOWARDS TECHNOLOGY IN EDUCATION: PLACE OF MAKERSPACE

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Abstract

Based on constructivist philosophy which focuses on enabling learners to generate knowledge through interaction with physical objects, the idea of makerspace was initiated. The main essence of makerspace is to stir creativity, innovations and motivate learners towards designing and inventing. This paper is an exposition on the place of makerspace as a new approach to pedagogical activities. The 21st century is immersed in information and communication technology revolution which has necessitated a new way of learning. New generation of learners are referred to as digital natives who are naturally gravitated towards new innovations. This paper relies on recent scholarly publications to point out intricacies of makerspace, the need for educators to embrace it, the new role for educators and other stakeholders in education and the need to manage this change in the educational system. The paper also points out the challenges that this new wave encounters in areas where adoption has taken place and the benefits of adopting makerspace. Conclusion is however made that change is constant and the idea of makerspace may be the new shift that will totally revolutionize the academic world. It is suggested that Faculty and Management need to encourage studies to evaluate accruable benefits of makerspace.

Keywords: Makerspace, education, technology. STEM, learning process, learners.

1 INTRODUCTION

Makerspace is a shift in approach to teaching which ([1], p.7) termed 'turning knowledge into action'. This involves encouraging learners to think creatively and giving them the opportunity to do collaborative thinking, practicing, forming and creating new 'things'. [2] has pointed out that Makerspace is a place to allow the minds of learners to do creative thinking and get access to enabling resources that could help them bring their thoughts into reality. Makerspace is also synonymous to teachshops, fablabs, learning commons, hakerspaces, libraries makerspaces etc., ([3]; [4]). The idea of makerspace is pivoted on the constructivist ideology which promotes constructionist educational approach [5].

It has been observed by [6] that Makerspaces encourage personalized learning. Although the concept of makerspace appears to be new, the rate of its spread is high. It is common in elementary and secondary schools while higher institutions are gradually encouraging its establishment for collaborative research known as learning commons. It is envisaged that this form of collaboration will birth inventions that could lead to major breakthroughs in science, technology, engineering and mathematics (STEM) [7]. It has been argued by [8] that level of access to relevant physical objects will determine the level of innovations that will be brought about by students. Studies also agree that children develop psychologically through exposure to some physical objects ([9]; [10]).

The crucible that houses the makerspace concept is the constructivist which emphasizes 'learning by making' philosophy [5]. The maker culture calls attention to creating the space for amalgamation of science, technology, education, arts and mathematics (STEAM). This platform will encourage interaction among all these divisions [11]. A point of convergence for interaction among students and faculty engaged in science, technology, engineering, arts and mathematics (STEM) has become necessary.

Gap has been identified among these subject areas that there is no distinct point of convergence for interaction but individualistic approach to problem solving [12]. It is reasoned that graduates of science, technology, engineering and mathematics have high tendencies to work in related industries after graduation, why can't they begin to interact from school? [13] opined that STEM relationship

ought to have started from secondary schools, extending to higher institutions and partnership after graduation. The idea of makerspace is to form a family of makers from tender age and develop this orientation to affect choice of careers, hobby and engagements among students. Peer-supported activities have been recorded to have positive impacts on learning [14].

2 CONVENTIONAL LEARNING AND MAKERSPACE

Learning is an activity that takes place either consciously or unconsciously through various means and via diverse educational and instructional media or devices in a formal learning environment like the classroom, lecture theatres, libraries, etc. ; or an informal learning environment such as through contact with mass media, discussion groups, etc. [15]. However, the conventional learning mostly takes place under formal learning environment but it is imperative to observe that in this twenty-first century there is a gradual shift to the use of technologies and inculcation of dynamism in the process of teaching and learning as a result of the proliferation of information and communication technologies into various aspects of life including education.

The process of learning now involves to a large extent hands- on experiences which go a long way to enhance the entire learning process and encourage young learners who could be discouraged by the usual convention method of learning because most of them have been exposed to information and communication technologies from a very young age and see the conventional learning process as boring since there is little or no use of digital technologies and other practical tools [16].

One major type of hands-on means of learning is through the use of Makerspaces. This involves the process of teaching, learning and impacting knowledge through practical, hands-on, 'out of the box' methods. [17] defined makerspaces as 'creative spaces where people gather to tinker, create, invent, and learn.' Makerspaces are further explained as 'spaces for creation where digitally controlled machines are used to build practically everything and where knowledge is interchanged among the team members' [18].

The concept of Makerspace allows for the process of learning with a touch of playfulness which brings about better effectiveness in the process of learning quite different from the usual conventional learning scenario. This point was further buttressed by [16], who noted that play is a core part of the use of makerspace for learning and this helps to drive the engagement in the process of learning especially among young learners. They further reiterated that in the process of learning, it is important that ample physical space and time be provided for social and emotional development because these serves as a platform for the learners to build their capacities through interactions with these gadgets/tools available in the Makerspace. In the same vein, makerspaces in learning makes room for learners to engage in Kinaesthetic learning, where learners or students are involved in carrying out activities and not just listening to long lectures and this has become very popular learning style because experimentation ensures better assimilation of the subject matter than theory [19]. The use of makerspace in the process of conventional learning and teaching has also improved the process of creativity among learners; this is because they are more exposed to practicals, dialogues and discussions. They can now have a practical touch to the usual theoretical teaching method which makes concepts look very abstract.

[18] opined that Makerspace environments are also known to serve as a good platform for Problem based learning especially among learners in the field of engineering because this innovation gives room for divergent thinking among learners and their instructors making the process of learning highly experimental, collaborative, challenging and interesting. They also noted that the inculcation of makerspaces in the process of learning has brought about great level of decrease in the level of absenteeism and improvement in the level of academic performance of students in the field of Science, Technology, Engineering and Mathematics.

Makerspaces has a positive influence on learning simply because its approach to learning is the 'do it yourself' approach which places the challenge on learners to think outside the box and not just waiting to be spoon fed by their tutors and also practice what has been impacted to them in theory; in other words, a lot of emphasis is placed on creative experimentation [4]. The inculcation of makerspaces in conventional learning has a positive effect on the learning process and in the long run, the learner; because it uses the instrumentation of hands on learning, which is a catalyst to the building of well-furnished learners is.

The use of makerspaces in learning can also be likened to the Experimental learning process which has become a staple in the American Education system since 350BC when Aristotle wrote 'for the

things we have to learn before we can do them, we learn by doing them.'[20]. It is therefore safe to say that the introduction of makerspaces in the process of teaching and learning would in the long run increase retention and engagement by the learners especially young learners; create better opportunities for solving problems; give unique learners (such as an auditory or kinaesthetic learner) better platform to assimilate subjects and encourage practice which would lead to perfection.

2.1 Constructivist Learning Theory

Constructivist learning theory is pivoted on the idea that persons tend to have permanence in learning after experiencing the practical aspect of what is taught theoretically. This connotes that persons are able to make deductions from experience and this leads to creativity. Piaget and Vygotsky's cognitive theories encompass constructivist thinking. While Piget focuses on active learning, scheme creation, assimilation and accommodation of all forms of science; Vygotsky emphasizes social constructivism, group work, internships etc. It can therefore be concluded that constructivist thinking is the foundation for "topdown" and "bottom-up" learning methodology. It also implies that students have the opportunity to gather details of subjects of interest after they have received basic ideas from teachers. This allows for independent and creative thinking [21].

The idea of constructivism is based on cognitive development through interaction with the environment. Knowledge develops as learners are exposed to prevailing situations in the environment and they are allowed to think solutions. This leads to birth of new knowledge. Constructivism allows for learning, unlearning and relearning based on the prevailing needs. Adjustment arises infinitely through the process of reconstruction [22]. Constructivism is mainly concerned with the learner understanding the emphasis. The thinking process of learners should be developed and learners should focus on active personal knowledge development. This implies that the learning outcomes depends more on the learner through active participation and creative thinking. This will help the cognitive domain of the learner. Learning in constructivist's view relates to experience in the laboratory, active interaction with colleagues and collaboration to ensure successful implementation of concepts developed in the process of interaction [23].

2.2 Benefits of Makerspace to New Generation of Learners

Several benefits may be derived through adoption of makerspace in the educational system. This new approach to learning has the potential for development of children and their learning process. Problem-solving skills, curiosity and creativity could be fuelled through makerspace. High level of imagination, inquisitiveness and motivation characterize students that usually get involved in activities that involve the use of hands and brain ([24]; [1]; [25]).

It has also been noted by [26] that makerspace allows for interdisciplinary relationship which helps to prepare young learners for the unfolding careers of the future. The opportunity created by makerspace arouses the need to use the hands and the brain to invent new things. Passivity among students could also be reduced significantly as a result of opportunity for interaction among people and things. This has been succinctly presented by [6] that the capacity to take control of one's life, take responsibility for one's learning and be more active could be developed in the process of engaging with things.

A very important component of makerspace is that it affects the thought process of learners. [27] emphasized that the making process is more important to students than what is finally made or may not be made, stating that the process significantly affects the thought vision, thought and the connecting capacity of the maker. [6] observed that students begin to develop trust in themselves when they are given opportunity to try making things on their own with available materials in the space provided for them. Children who have access and use makerspace resources grow up to develop risk-taking techniques.

The peculiarity of makerspace reflects in the mode of learning. The teacher is not the sole facilitator; students also sometimes assume the teacher's role as they explain their discoveries and crafts to teachers and fellow learners. Independent thinking and exploration take place through makerspace. Collaboration and autonomy are encouraged as students continue to figure out the best approach to solving a specific identified challenge [5].

The makerspace era is opening the door for emergence of new careers that are beyond the theoretical class within the four walls of the classrooms. Accidental inventions may take place in makerspace and that could open up lots of opportunities for the new generation of job seekers.

With the possibilities embedded in the ICT era, several innovations are emerging. The makerspace couldn't have come at a better time than now. New skills are being required in the work place now due to new ways of thinking and new sets of tools that organizations acquire. The makerspace serves as the incubator for skills development ([6], p. 3; [1]; [28], p. 23). Furthermore, makerspace encourages community participation in the teaching process, artisans and professionals who have hands on experience of some technical aspects some subjects of interest to "Makers". It also caters for cross-generational learning as different age groups are engaged to ensure cross fertilization of ideas ([1]; [27]).

Makerspace encourages interdisciplinary learning as students from different subject backgrounds converge in a space that promotes cross-fertilization of ideas. [6] asserted that the dichotomies among several disciplines need to be bridged as the real world thrives on fusion of disciplines. Communication, science, engineering, arts, medicine, economics and other disciplines are the pivot for sustenance of any human community, hence the need for their interaction in schools and colleges become paramount. The maker movement is redesigning the educational structure through innovative approach which affects students, the learners and the community. The makers' movement has great potential to make students change agents [28].

2.3 New roles of educators and learners in the 21st century

Stakeholders have been rethinking approaches to teaching and learning process in the 21st century. Specifically, teachers and students need to acquire new skills, develop certain attributes and prepare to constantly embrace continuous change which characterizes the 21st century. The teacher is no longer seen as the 'sage of the stage' but 'guide on the side'. The teacher assumes the role of facilitator and mentor while students assume several roles as inquirers, co-facilitators (peer-tutoring), inventors, and adventurers. Learning has moved from physical to virtual, 'breaking' the four walls of classrooms. Four trends have been identified to characterize the education sector in the 21st century, they are termed as the 21st Century Skills; Bring Your Own Device (BYOD), Digital Game Based Learning (DGBL) and Makerspace. These require teachers and learners to acquire new skills and new ways of thinking in order to maximally benefit from these trends [29].

Learning in the 21st century calls for new roles for teachers, students and technology. [29] suggested three new roles of teachers in new paradigm of instruction:

2.3.1 Learner as a worker

This learning process places demand on learners as they are expected to get engaged working on something in order to learn. The teacher designs what facilitates learning while the learner works on the design to achieve. This emphasizes the need to translate the theory into practical, enabling students to visualize the reality of the designs made by teachers. The skill of teachers in helping students to be creative comes to bare in this new role.

2.3.2 Self-directed learner

Emphasis is on the learner in this new role. The learner needs to be self-motivated, self-directed and self-reliant. This does not totally eliminate the teacher's responsibility but a deliberate attempt is made in the design of the programme to encourage students to look within self for solution to seemingly complex situation. The focus of this system is to encourage life-long learning which is not limited to the period dedicated to learning, which is the primary, secondary and tertiary levels of education.

2.3.3 Learner as a teacher

Learning has a high tendency to become permanent when what is being learnt is taught others by the learner. Peer tutoring is a novel model in teaching that engenders confidence in learners as they discover that their opinions and ways of thinking are adjudged acceptable and adopted by their peers.

New roles of technology in the new paradigm is to be a tool for learners to be self-directed learners for life-long learning and at the same time to fulfill 4 major functions for the teachers. These include a) Keeping track of students' progress, b) plan student project in project-based learning, c) facilitate instruction to provide immersed learning as in simulation and virtual leaning environment and d) provide personalized learning.

2.4 Specific Roles for Teachers

2.4.1 Progress Monitoring

Teachers need to ensure that they are abreast of improvements experienced by learners on the 'Do it yourself' scheme. Having designed the learning scheme and the step by step approach, the teacher further engages on constant evaluation to ensure that students stick to agreed terms that will ensure learning. Students in the process of trying hands on several 'things to make' may come up with inventions or discoveries that may lead to a new breakthrough. It is therefore paramount that teachers are aware of these developments on time in order to offer useful counsels to materialize the student's intention. The teacher may not have the capacity or skills to properly guide the student in this new line of discovery, however, there may be other professionals whose experiences are germane. It is the duty of the teacher to involve such persons. Teaching and learning therefore are taking the partnership dimension between the teacher, the learner and community.

2.4.2 Planning Student Project in Project-Based Learning

This approach is student-centered, inter-disciplinary and rigorous but socially and intellectually stimulating. The teacher in this system of teaching assumes the role of facilitator, encouraging student to adopt the best option in finding solutions to problems. Although the process is rigorous as it is a departure from 'read, memorize and deliver pedagogical process', the process allows for inquiry into real-life problems and solution devising. Several academic contents are engaged to ensure specificity of solution. This rigorous process is usually cushioned by teacher's advice on the forms of academic resources such as libraries, laboratories, persons and other resources to contact. Teachers are expected to expose students to inter-disciplinary approach to confronting challenges as real-life challenges are not confronted based on a single domain.

3 LEVEL OF ADOPTION OF MAKERSPACE

The idea of makerspaces has been gaining strong ground and also fast being adopted in various educational institutions across the globe. [30] noted that in the United States of America, there are quite a number of institutions that have adopted makerspace as a platform for providing experimental hands on experiences for learners and also an instrument for increasing creativity and encouraging innovation. Some of these institutions include the University of Ottawa's Richard L'Abbe Makerspace, which was established in 2014; the Invention Studio at Georgia Tech, Taubman School of Architecture's FabLab, University of Victoria MakeLab.

Also in Australia, the University of Southern Queensland, specifically the Toowomba campus, has a well-functioning makerspace. A study carried out by [31] of forty-three Australian universities revealed that twelve have makerspaces and three out of these few have two makerspaces dedicated for this purpose, these are the University of South Wales, University of Sydney and Manash University. In view of this, the United Data Technologies (2017) noted that a good number of K-12 schools have embraced the idea of introducing technology into the classroom as it would speed up the process of learning and improve educational experience.

In Nigeria, the level of adoption of makerspaces is still at the early stage. According to the [32], the Prikkie Academy team established a makerspace in September, 2017; where youths could enhance their level of creativity and innovation, participate actively in problem based learning which will build and enhance the process of learning in the long run [31]. [33] in her article on titles 'Making a Makerspace case for academic libraries in Nigeria', highlighted that the Centre for Technical Vocation Education Training and Research Mobile College established in 2015 serves as a mobile makerspace established by the University of Nigeria, Nsukka. With the full adoption of makerspace for learning and teaching in Nigeria, the process of learning will take a new positive turn and this in the long run would better the Nigerian economy.

3.1 Makerspace and Challenges

The introduction and utilization of makerspaces for learning and teaching no doubt has brought about positive results in the process of assimilation, retention and understanding by learners especially those within the younger age range however, there are some challenges or bottlenecks involved in the process of using makerspaces in learning processes. Some of these challenges as highlighted by [34] are explained below.

It is an established fact that makerspaces are made up of various gadgets that will enhance participatory learning and these gadgets are usually capital intensive. Books and other learning resources are also expensive but not as expensive as some of these gadgets that would be used in any makerspace. Some of these gadgets include 3D printers, laptops, computers, laser cutters, soldering irons, propellers, sewing machines, etc. These devices/gadgets costs a lot and may be difficult to acquire with the limited fund made available hence it could pose as a major challenge to the establishment of makerspaces. [35] corroborated this point by noting that

> *'Funding is perhaps one of the biggest obstacles libraries will come across when trying to design a makerspace of their own. A lot of the implemented hardware is relatively expensive and it may be difficult to prove the worth of a makerspace because of the high costs of starting one'.*

They however suggested that funds could be sourced from grants and other special donations and libraries that want to start new makerspaces should use cheaper devices such as laptops and computers rather than going for expensive gadgets like 3D printers. They further unequivocally stated that 'by starting small and using some of the available online tools that can be used for creating, libraries can inexpensively display the value of a fully-formed makerspace [35].'

After equipment to be used in the makerspace are acquired, there is also the issue of regular maintenance and replacement of the equipment peradventure they are damaged by the library users and this could also add to the cost of running the makerspace. [36] however noted that in some libraries, the cost is borne by the library user. He stated that in the Darien Library Digital Media Lab, when any equipment is damaged or lost by a library user and everyone with him or her in the makerspace, the library account of those users will be debited with the replacement fee as determined by Darien Library.

Personnel training could pose another challenge to the establishment and maintenance of a makerspace in any library. This is because the responsibilities of the librarians would be further increased to accommodate the efficient running of the makerspace. The librarians need to be trained to proficiently utilize all the gadgets in the makerspace and even tutor the learners if the need arises. When these training are not carried out frequently and effectively, it affects the running of the makerspace and may probably lead to the damage of the equipment available. It is therefore paramount that librarians are trained regularly on how to operate and manipulate every equipment available in the makerspace. It is pertinent to note that these training for the smooth running of the makerspaces are also time consuming and could discourage the librarians.

Another common challenge that could be encountered when using makerspace in the process of learning is that of physical space. Makerspace require large rooms to contain equipment and allow for experiments. When there is little physical space available in a library for studying and housing of the library's resources; it become an herculean task to think of establishing a makerspace in that same library because of the size of the gadgets that would be housed in the makerspace.

Availability of skilled human resources and time constraint to effectively and efficiently run the makerspace could also be another obstacle to the establishment and utilization of makerspaces in libraries. The library staff that would be stationed in the makerspace would be responsible for the running and operation of all the equipment and software in the makerspace hence they need to be IT savvy and well skilled in troubleshooting in case the need arises. [4] averred that it is important that the librarian responsible for makerspaces must possess firm understanding of appropriate pedagogical practices, be experienced in handling materials and equipment, and must possess sufficient self-efficacy to implement unfamiliar curriculum and navigate unanticipated problems. This is usually a very demanding responsibility and may pose to challenge to get librarians to carry out these functions especially when it has to be a combination of various responsibilities like in the case of teacher-librarians. These group of people have to combine both teaching and librarianship, they could have challenge of limited time and scheduling of their available time. The issue of scheduling may also be a challenge on the part of the learner, the learners may have challenge joggling classroom time with time spent in the makerspace [6].

Resistance to change is another challenge that can be encountered. Humans are sometimes rigid and do not like to change from the usual pattern of doing things. This resistant attitude on the part of the library staff and the library users and learners may pose a challenge to the use of makerspaces. [37] as cited by [34] however suggested that this challenge can be tackled by providing staff development programmes and incorporating effective change management models prior to the implementation.

Another challenge that may be encountered in the use of makerspaces is the problem of noise management. Due to the nature of some of the equipment in the makerspace, there may be a lot of noise coming from the makerspace which could affect other library users and learners hence the problem of noise management may come to bare. It is only necessary that the walls physical location of the makerspace should be sound resistant to avoid distracting other learners outside of the makerspace.

Erratic power supply could also be a challenge to the use and establishment of makerspaces. In a situation where there is no steady electricity supply or alternative energy giving source; a good number of some of the gadgets available in the makerspace will be rendered useless or even end up getting damaged.

4 CONCLUSION AND RECOMMENDATIONS

Makerspace is a highly promising pedagogical approach in the 21st century and its adoption is on a constant growth. This new approach to teaching and learning process however requires acquisition of new skills by teachers and students. Students have the opportunity to do independent exploration of ideas as they collaborate with their peers in science, technology, engineering, arts and mathematics and this collaborative effort may lead to major breakthroughs in several disciplines that proffer solutions to human challenges. The study recommends that Stakeholders in education should give maximum support to makerspace as several facilities may be required for its materialization. Teachers also need to open up to this new approach through their willingness to learn new skills and collaborate with other professionals. Awareness programmes on makerspace should be constant at the early stage until the approach is totally ingrained into educational system at all levels.

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