Information and Communication Technology (Ict) Integration Into Science, Technology, Engineering And Mathematic (Stem) In Nigeria

A.A. Ojugo.+, A. Osika++., I.J.B. Iyawa* and R.O. Yerokun (Mrs.)**

+Department of Mathematics/Computer Science, Federal University of Petroleum Resources Effurun,
Delta State (+234)8034072248, ojugo_arnold@yahoo.com, ojugoarnold@hotmail.com
++Computer Science Education Department, Delta State College of Physical Education, Mosogar,
Delta State. +2348060328840 (osikaangela@yahoo.com)
**Computer science Education Department, Federal College of Education (Technical), Asaba,
Delta State. iyawaben@hotmail.com, agapenexus@hotmail.co.uk

Abstract

As Nigeria aspires for technological growth, positive changes need be made by placing proper educational values towards Science, Technology, Engineering and Mathematics (STEM) education. Some problems faced by STEM include lack of qualified teachers, curriculum, the misconception that STEM education is reserved for the less intelligent in the society, amongst others. Need thus arises, to develop alternative strategies to alleviate such problems. Bridging ICT and constructivism will exponentially change educational processes of both teachers and students to succeed as well as present new forms of learning environment. It will also unveil the power shift in educational structures; equip students to become knowledge producers rather than consumers. Thus, an ICT-Constructivist rich class will help teachers enfranchise, emancipate students academically with a framework that measures quality of engaged student's learning. This paper aims to reveal links between effective use of ICT and the long neglected theory of constructivism in the area of STEM Education.

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1.0 Introduction

STEM has now become an integral part of our culture – in that actualizing our current societal goals and those of our generations ahead will be a mirage unless we have excellent understanding of STEM. [1] points that STEM has become our heritage and mankind's hope. Thus, the mission of today's education must ensure students are scientifically literate to cope with technological changes of the **data** age. [2] notes STEM goals as: (a) provides preparation for training in science and mathematics, (b) provides basic mathematics and science literacy for everyday living, (c) provide basic skills, attitude to prepare us for technological developments and (d) help stimulate and enhances creativity.

Education is the art of transferring knowledge from a teacher to learner within a physical environment (called **school with classroom**) and interrelationship that [3] calls a **system** of factors, which jointly affect learning individuals of cultural differences. The classroom provides the structure in which learning is organized and the school has three major components namely: learner, teacher and administrator. There are basically two styles of education delivery namely **Traditional** (a teacher employs face-to-face, oral method in which the teachers pass knowledge to a learner), and **Alternative Delivery** (learners can construct new knowledge and meaning from previous concepts and beliefs with methods and strategies that involves media literacy. The **latter** is more concerned with what a learner does and understands rather than teacher's input. Thus, the use of equipments becomes **focus** of study (technology education) and educational **support** (educational technology) as in figure 1 [2,4].
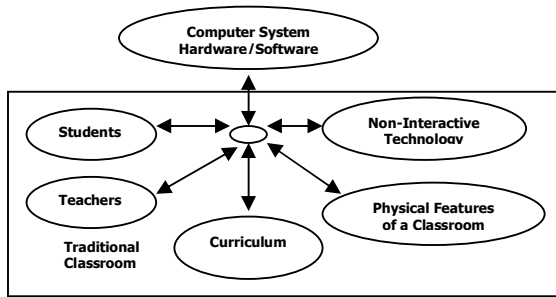
Figure 1 shows a constructivist-class model

[5] laments that STEM education is not given serious attention as it is misunderstood by educators and stakeholders in Nigeria, who believe that STEM education are for those who cannot pursue academic programmes. Thus, proper values must be placed on its need to help attain the **desired** growth as today's industrialized nations employed the skills of both the **educated** and **less** educated in their growth toward ICT. Technological advancement in Nigeria today, is a sad reflection of the poor quality of STEM education that still receives stigmatization in our educational system, hindering our expected technological progress.

1.1. Objective of Study

The study objective is: (1) seek alternative exemplary educational practices, (2) showcase outcome that describes individual/group adoption patterns of technology in learning as well as (3) show evidences linking technology integration, quality students learning and staff development.

1.2. Statement of Problem

This study investigates learning in technology rich class (constructivist) versus the traditional class (non-constructivist) via creaction of a constructivist and non-constructivist groups. Will constructivism make a difference via meaningful, engaged-learning and transferable knowledge by students, in their own context? It will also seek the extent of the success in constructivist learning as *effective* method to boost student's learning, performance and achievement.

1.3. Research Question

The study aims to determine:

a. Extent of student's achievement and attitude in a constructivist and non-constructivist

groups as reflected in their learning of STEM.

b. Impact of ICT on various learning processes.

c. What is the rationale behind ICT integration.

2. 0 ICT Framework In Education

The provision of modern technological equipment at all school levels varies due to their various levels of preparedness – both by teachers and students. A look at students' ability in obtaining the necessary flexibility in the world of information closely correlates amongst others, level of information setting of schools as this will help provide schools with various expanse of data in printed and electronic format via regular updates and networks as well as those directed by experts in the informatics field.

ICT integration into education results in great reforms to the learning process; and educators who advocate such reforms, opines that such learning is informed by constructivism [6] which pleads the need for students to develop high thinking skill and the failure of the current schooling methods to provide such opportunities [7-8]. Thus, a critical factor to ICT integration is **constructivism**, so that learning takes place as the learner completes tasks for which *media* support is required and used to maintain such learning environment and learners [9].

Technology creates ideal learning. Thus, [10] notes it has been ignored or its past implementation has failed widely – as it creates a learner-centered, learning environment with a belief that they learn more from what they do or think rather than the teacher's input. But we must take care not to allow the dynamic nature of technology overshadow the enduring nature of learning and or the ever-increasing knowledge base about learning [7, 4].

[11] notes the concept of **constructivism** as one in which a learner has the ability to actively construct knowledge as he learns. It also emphasizes knowledge as a construction of reality in the learner's mind because knowledge is a dynamic adaptation towards an interpretation of experience. It supports many interpretations to reality based on knowledge constructed from experience and media-rich class. It focuses on knowledge **construction** rather than **consumption** – as the learner constructs data from experiences and mental beliefs, interpreting events accomplished outside the mind. We thus see the world we describe rather than describing the world we see. When

integrated across curriculum, it provides appropriate level of difficulty due to its tasks that are of real world relevance with engaged-learning and teachers becoming knowledge guides [12] as seen in figure 2.

2.1. Constructivism

Today's education is transformed by new technologies that provides large amount of data to learners, coupled with the fact that knowledge doubles at increasing speed requiring a transformative method to education. Its challenge is that educators and learners are *suspicious* of the educational practices as it differs from what they are used – as constructivism removes *statewide* assessment, which traditional model promotes by *aligning* tests. The issues of fund shortage, unclear vision to keep the change from occurring rapidly as well as teachers not having a good understanding of how ICT works as they are charged with the duty of emancipating students, are in continual resolution. This paradigm shift will require teachers' retraining, role redefinition as well as acculturation to put this systemic change in place – even though it be slow [13].

[14] notes some of the known principles of the constructivist learning as thus:
1. Learning is *active* and consists of meaning construction and constructing system for meanings.
2. Knowledge construction is *mental* – since it happens in the mind of the learner.
3. *Language* influences greatly what we learn.
4. Learning is a social activity associated with connections the learner makes with others.
5. Learning is *contextual* – as learner cannot learn isolated facts or theories in abstract ethereal land, separate from real world situations.
6. *Motivation* is a key in learning to help us know how the acquired knowledge can be put to use.
7. *Knowledge* is important – as we cannot comprehend new ideas without some structure developed from prior knowledge to build on.
8. Learning is not *instantaneous* but takes time – as the learners must revisit principles, reflect on them and using them as often as possible.

2.2. New Paradigms: A Constructivism Class

Education, transformed by new technologies yields the following paradigms, when adopted:

a. Shift from whole class to smaller groups
b. Teachers coach weaker students rather than focus on all as with traditional settings. Coaching occurs rather than lecture and recitation.
c. Students become actively engaged, cooperative and less competitive
d. Students learn differently than simultaneously.
e. Integrate visual/verbal thinking rather than primacy of verbal thinking as in traditional class.

Thus, educators, parents and learners will become *suspicious* of the educational practices as it differs from what they are used. This is becasue such constructivist learning removes *statewide, aligned* assessment – unlike traditional model. Thus, learners will take *standardized* tests, which does not assess *what* they are learning but what new meaning they derive of concept. Class structure will become more *fragmented* and problems will abound due to lack of funds and unclear vision to keep this systematic change from occurring as rapid as possible. Teachers charged with the duty of emancipating students, may not have adequate understanding of how these technologies work and the amount of data available as such paradigm shift requires staff retraining, their roles re-defined to inform them to think about why they do what they do as well as funding [15-20].

2.3. Challenges of Constructivism

The common challenges of constructivism as:
1. **Nativism**: Cultural constructivism promotes nativism and language, which primarily distorts the fundamental unity in education generally. It thus denotes knowledge as meanings conveyed by learners in different tongues – though referring to same state. Meanings, applied are inseperable of linguistics; though, science views meaning as an objective states that transcends such linguistic boundaries. It thus proposes to recreate nature to suit cultural and linguistic boundaries. But, the nativism and empiricism of science are too parallel and may never meet at internationalization and globalization [21].

2. **Knowledge Territorialism**: A concept of false belief that Africans who live enclosed cannot yield scientific discourse. Knowledge transcends the idea of cultural boundaries – such that ideas from varied ccultural perspectives

must converge a conventional consensus due to similarities over their differences – though, such similarities by virtue of their many appearances, imprints itself upon the mind; while individual differences that changes between cases, fails. Faraday, Newton amongst other scientific inventors made their ideas to transcend ethnic boundary. Thus, we must deterritorialize our seminars to hold global focus; instead of its localized viewpoint [5].

7.1   Globalization: Poor globalization in
STEM is often misconstrued as nativism. Scientist must ensure unity via interaction and exchange of concepts, innovations and skills among experts world over. This will urge individuals and research organizations not to be localized and restricted by culture. Competition must be encouraged, with knowledge circulation a rule. Thus, cultural constructivism in education is faced with the challenge of capacity building and establishment of research networks with Africans in Diasporas and with other worlds [21].

3. 0 Method And Materials
This will be discussed under the following heading: 3.1 and 3.2 respectively.
3.1. Researchable Model:
The researchers will adopt [22] researchable model as redesigned by [5] for STEM education. Teaching method will be divided into *constructivist* (via laboratory, Internet to allow online interaction) and *non-constructivist* (normal classroom) groups. Curriculum content in focus: Mathematics (Geometry), Biology (Reproduction), Physics (Pendulum) and Chemistry (Titration). Feats to be measured include teachers'/students' attitude and involvement.

3.2. Population
Nigeria, is today divided into 6 geo-political zones: South East (SE), South-South (SS), South-West (SW), North-North (NN), North-East (NE) and North-West (NW). The scope of the study is limited to tertiary institutions in the 6 geo-political regions. Two schools were chosen from each geo-political zones: Federal University of Petroleum Resources Effurun and University of Port-Harcourt (SS zone), University of Nigeria Nsukka and Imo State University Owerri (SE zone), Osun State University and University of Ibadan (SW zone), University of Agriculture Maiduguri and University of Jos (NW zone), Ahmadu Bello University Zaria and Nigerian Defence Academy Kaduna (NN zone) and lastly, Idah Polytechnic Idah and University of Illorin (NE zone). From these, 15 samples each were selected for the constructivist and non-constructivist groups (i.e. 30 students and 30 teachers) – and the sstratified sampling method adopted, in the selection criteria to alleviate falsehood of results obtained as well as give a fair representation of population.

4. 0 Data Analysis And Findings
Pedagogical practice and extent of involvement will determine if a group exhibits characteristics of a constructivist class or not. Its outcome is measured via assessment of student's performance as seen in figure 3. For analysis, mean (X) and standard dev. (SD) are used with results discussed below in:

4.1. **Research Question 1:** ICT integration impact on students and what extent their achievement is reflected in their attitude?

Table 1a. Mean score of student acheivement in two gruops

		Pre-Test		Post-Test	
Groups	No.	Mean	SD	Mean	SD
Experimental/Constructivist	720	13.8464	3.124	21.4333	4.150
Control/Non construc-tivist	720	10.625	2.561	19.4027	3.484

Table 1b: Student's attitude towards STEM in two groups

Groups			
	No.	Male	Female

	No.		
Experimental or Constructivist	720	10.1663	9.9823
Control or Non-Constructivist	720	11.0001	10.0011

Table 1a shows the differences in students'mean score achievement. At post-test, students in the constructivist group had a higher mean scores than their counterpart in non-constructivist group. This is attributed to the exposure they had in the use of ICT in learning. While table 1b shows a significant difference as male students in the non-constructivist group exhibited higher attitude to STEM than their counterpart in constructivist group. This can be a result of *technophobia* as they were introduced to a completely, new-pedagogical learning pattern and scenario. Thus, ICT supports learning with technology literacy, high academic emancipation from teachers, increased motivation for learning, improves their achievement in core subjects as measured by tests, increases their engaged learning and interdependence that allows them develop skills that are associated with time and resource management, concentration, self-discipline, attention to defined task and ability to follow instructions. Any change in role and requirement for new sets of skills to be introduced/supported, must be carefully done with consideration for learners with opposing perception and poor past experiences. It is also discovered that students use ICT in different ways because more access requires greater personal responsibility that is lacking in some students.

4.2. Research Question 2: ICT integration impact on teachers and attitude reflection?

Table 2. Teachers attitude towards STEM in two groups

Table 2			
Groups	No.	Male	Female
Experimental or Constructivist	720	14.663	9.660
Control or Non-Constructivist	720	11.001	8.912

Table 2 shows significant difference in the experimental group as teachers are more at home with the idea that such courses must and should be taught in technology-rich classes. ICT integration requires a complex change, as teachers must remain instructional *leaders* to aid human interaction, motivation and to retain their established influence over directing class activities. Teachers must reflect on ICT's impact on their roles and on the learner. Teachers seeking to employ ICT note the issue of curriculum, learning materials, ICT usage in classroom, student roles and behaviour – as they must be provided with information access that leads to increased interest in teaching and experimentation. Such learning requires more collaboration from administrators, parents and students with proper planning, energy, skills development and knowledge of ICT. This will lead to greater productivity via more engaged time for learners and presents a pedagogy with strategies that are: (1) learner-centered and active, (2) more cooperative and collaborative, (3) learning based on great information access and source, and (4) create in learners, the need for interdependence.

4.3. Research Question 3: ICT impact on Learning and Its Environment.

ICT offers new learning methods, allow teachers to rely on educational theory and past knowledge of educational situation to aid better decisions about what/how the learning environment will look like as well as improve overall effectiveness of learning environment. Its positive impacts are: (a) class-size reduction, (b) increased learning time, (c) better performance via the use of cost effective computer aided instruction (CAI) programs, and (d) significant gains in learning as ICT learning is mediated via components like curriculum, teachers and pedagogy. ICT allows proper investigation of real world applications with vast amount of data access, and tools to analyze and interpret data as well as broaden and deepen knowledge. It also allows active participation and proper assessment of class activities. Students' engagement with curriculum will increase and afford them opportunities to create their own data and represent their own ideas. Simulation programs will help provide learners with learning experiences as they interact *offline* (with computers) or *online* (with others). Thus in all cases, students has more influence on learning as activities becomes more responsive to learners' need to better facilitate development

of theoretical framework and assist in deeper levels of learning.

4.4. Research Question 4: ICT integration impact on school Curriculum.

Curriculum is a two-way rrelationship – in that ICT is used to cconvey curriculum and vice versa, change the contents of curriculum. Report shows that effective use of ICT to support learning is a function of the curriculum content and instructional strategy such that when appropriate, contents are addressed using appropriate strategies that students and teachers will benefit from. The impact of ICT to curriculum can be viewed in terms of (a) declarative knowledge that describes events by specifying properties that characterizes them, and (b) procedural knowledge that focuses on the processes needed to obtain a result or knowing how. This model is dynamic with interactive multimedia that provides visualization and analytic tools that are currently, changing the nature and inquiry into STEM. These changes affect the kind of phenomena considered and the nature of argumentation and acceptance of evidence. Thus, curriculum must remain relevant to societal needs so that while at school, it forms the learner's foundation that helps them connect in meaningful and motivating ways as they apply it to their workplace – since at some stage, it becomes a trajectory needs to connect them with non-school discourses.

4.5. Research Question 5: ICT integration impact on the Education System.

Schools must provide infrastructure and support for learning to help maintain ICT integration and constructivist learning. [17] highlights seven requirements for ICT as: (1) Suiting technology to educational goals and standards, (2) vision for technology use to support curriculum, (3) provide in-service and pre-service training, (4) provide teachers time to plan and learn how to integrate the technologies, (5) ensure access to the appropriate technology, (6) provide administrative support for technology use, and (7) provide technical support for technology use. These falls into 5 areas as noted by [5]: (a) Provision of infrastructure, hardware and software, (b) Schooling, (c) Curriculum, (d) School design, organisation, policies and practices, and (e) Ttechnical support for teachers.

4.6. Discussion Of Findings

The study results show that there is significant difference exhibited by mean scores of students and of teachers in constructivist group over their counterparts in non-constructivist group. This confirms the view [5], that learning via the constructivist model paves way for meaningful, engaged learning and active participation and serves as motivational factor in learning.

4.7. Rationale For ICT Integration

The rationale is whether in practice, it has positive impact and must lead to a system that decides what students, teachers and the school, aims to achieve.

[23-24] notes that 3 main rationales are thus:

1. **Education Productivity:** Ratio of output over input is the quantity/quality of learning demonstrated by the student over cost. With the proper selection of input, learning is optimized to increased outcome. Productivity cannot be based on the fact that ICT media are expensive to install – as cases may arise in where ttechnology becomes the solution to a problem. If part of the curriculum is not completed for lack of technology, its associated outcome and productivity becomes zero.
2. **Technological Literacy** – ICT helps to address problems in curriculum. Education technology is selected on the basis that it has best feats for implementing the curriculum, as there is always a two-way relationship between curriculum and educational technology. *Firstly*, policy makers decide what to learn (curriculum), after which technology and the method to be used is determined by the intended curriculum. *Secondly*, new technologyy adds new feats to curriculum contents; while making some contents obsolete.
3. **Student's Learning Support** – There are much potential for the use of computers in learning but whatever the rationale, requires a critical evaluation on the part of students. We must bear in mind these criteria to be met on the learner's part: (a) managing high quality educational programmers requires large amount of data, which teachers must effectively help students manage, (b) Access to resource materials linked to teaching and learning (*online* and *offline*), and (c) computer literacy.

5. 0 Summary And Conclusion

This study contributes in four ways: (1) its outcome gives a description of individual and group adoption of technology for teaching and learning across the various educational levels, (2) images exemplary practices for teaching, learning and research; and (3) it links ICT integration, engaged students learning as well as staff professional development. Teachers and aadministrators having gained insight, must rise and equip themselves to make decision that will avert these problems, as they hold the keys to students success in this new education plan.

Its significance is both theoretical and practical as it highlights the folowing:

a. Increases awareness/application of ICT theories – naming issue and cchallenges with widespread adoption of ICT in education and outcome of curricular across subject areas in schools.

b. Hhighlights an adoption mode documentation and feats of administrators/teachers willing to integrate ICT with the support of network facilities. Our results shows, use of shared data instrument for widespread access by both teachers and students, based on engaged learning and the stages of technology adoption, will form the basis for the next step in the planning and implementation processes at each school. A useful information to all stakeholders in educations.

c. Education mode will provides the efficacious, much-needed images of integration for engaged learning – as such knowledge is useful, at organizational and individual level for staff development and ffurther research in such areas.

6. 0 Recommendation

a. Government must fund the integration and provide infrastructural support – as reform is not just the provision of ICT equipments.
b. Curricular reforms must be made to reflect ICT integration with reviews presented to the government for proper assessment and /implementation.
c. Staff development schemes organized by school administrators to equip and redirect teachers' focus to emancipatee students. This scheme and retraining, will aid teachers to better understand their new and *expected* role as well as will help them navigate a fully ICT integrated curricular.

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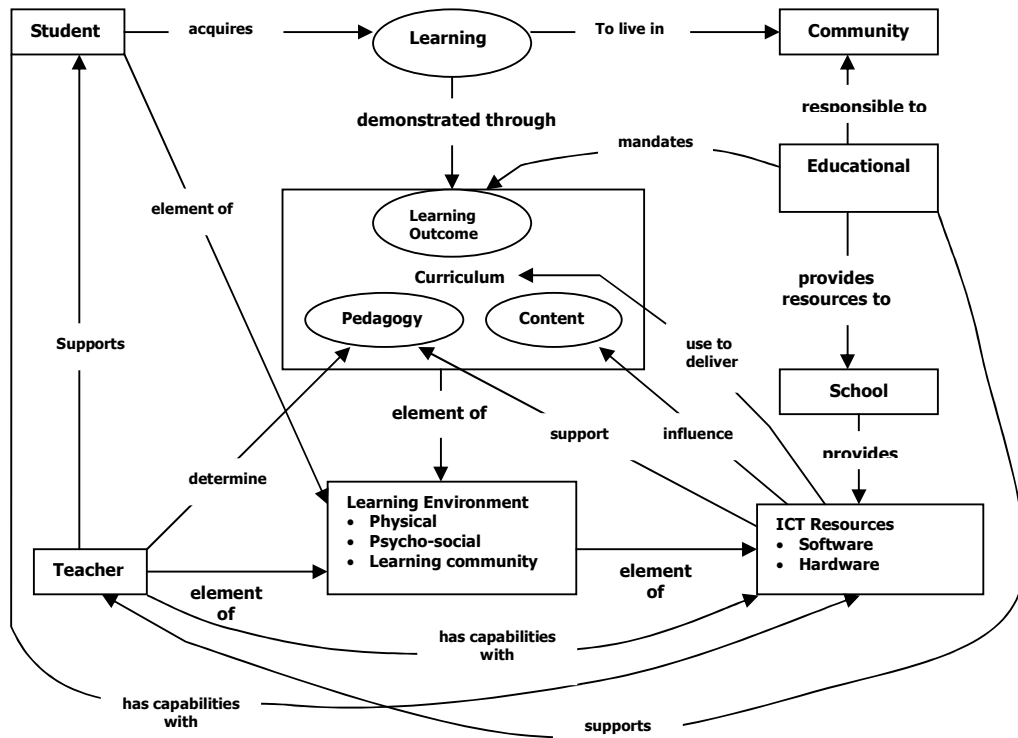
Figure 2 shows the concept map indicating the relationship between the learning environment entities and external entities
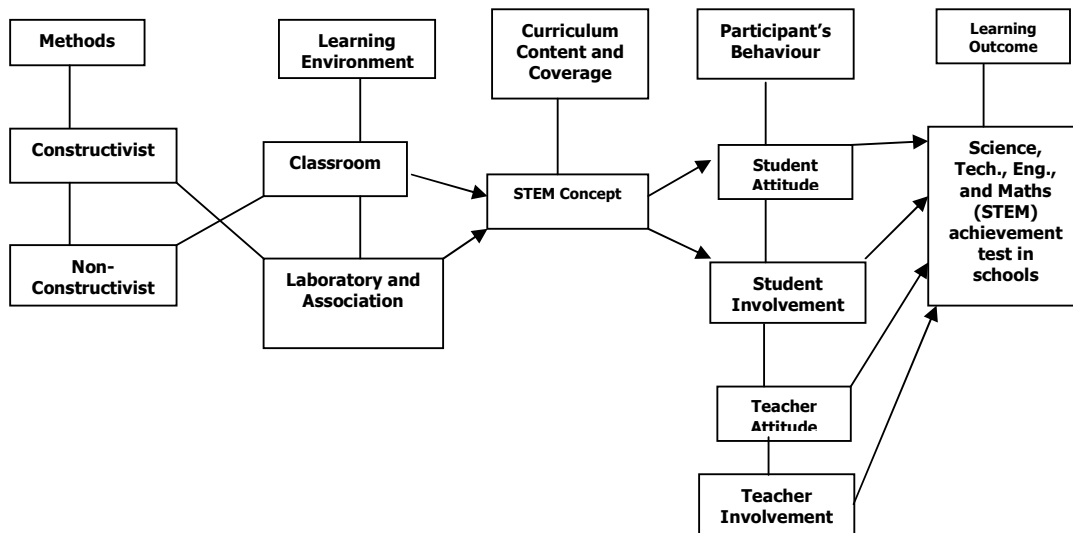

Figure 3 shows a researchable version of constructivist learning models using Yager's design