INFORMATION AND COMMUNICATION TECHNOLOGY INTEGRATION INTO THE EDUCATION SYSTEM FOR THE DEVELOPMENT AND GROWTH OF SCIENCE, TECHNOLOGY AND MATHEMATIC (STM): ISSUES AND IMPACT

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Abstract

Since Nigeria aspires to for technological growth and development, positive changes must be made towards her educational values as well as serious level of priority laid on the area of Science, Technology and Mathematics (STM) education to prepare her for the task ahead. Some problems faced in this area of education includes lack of qualified and competent teachers, non-technically related curriculum, the misconception that science and technology education (with special focus on technically related subjects) are reserved for the less intelligent in the society, amongst many other reasons. The need therefore arises, to develop alternative strategies that will help alleviate the problems faced by STM education. The advent of information and communication technology (ICT) and constructivism is exponentially changing our life options and the educational processes required for teachers/students to succeed presenting new forms of educational process and learning environment. ICT integration unveils a power shift in educational structures, equipping students to become knowledge producers instead of knowledge-consumers. A technology-rich class will help teachers enfranchise and emancipate students academically in a framework that measures the quality of engaged student's learning. This paper aims at revealing the link between the effective use of these modern technologies and the long neglected theory of constructivism.

Introduction

Fafunwa (1974) notes that we live in a world where science is an integral part of our culture. Thus, Nigeria as a nation must keep abreast with the fast developments laid by science and technology. He further stressed that unless we have excellent understanding of science and technology, actualizing our personal and societal goals, and for generations afterwards will be a mirage. Thus, Rowe (1993) stressed that science and technology is our heritage and mankind's hope. It is the vision and mission of today's education to ensure that students are scientifically literate to cope with technological changes of the ***information*** era. Abonyi (2005) notes the goals of science, technology and mathematics (STM) can be achieved through education aimed at:

a. Providing preparation for further training in science and mathematics
b. Providing the basic mathematics and science literacy for everyday living
c. Providing essential skills and attitude in preparation for technological developments
d. Stimulate and enhances creativity

Education is the process of transferring knowledge from a teacher to a learner, allowing both persons explore and come to full understanding of all that lies in their domain. This process occurs in a physical environment called ***school*** – forming a relationship Salomon (1994) calls ***system*** of interrelated factors jointly affecting learning interaction with individual of cultural differences. A school has three components: administrator, teacher and learner. The classroom provides the structure to describe a setting in which learning is organized, and the role of teachers and learners occur.

However, it does not identify the ***purpose*** of setting up such an environment (which is dependent on the beliefs and actions of those responsible for setting up the environment).
There are basically two styles of education delivery namely:

a. ***Traditional*** – A teacher employs a face-to-face and oral method to pass knowledge to the learner, with specific processes and focuses his knowledge production on the *curriculum* while the learner consumes it by attending the classes. The teaching process is simple with non-flexible contents and timetable that allows a ***knit*** relationship between teachers and learners. Learning depends on the teaching methods and facilities, with experiments and/or practice that help to increase and quicken understanding of concepts (Ojugo, Aghware and Eboka, 2006). Most schools adopt the pattern – the only difference is their relationship and emphasis with the kind of schools as in *figure* 1

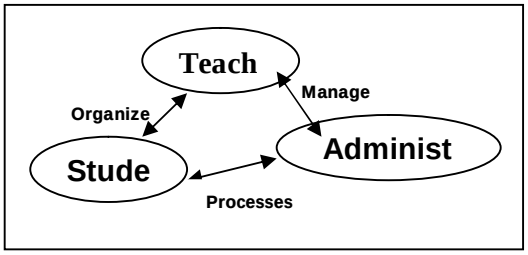

Figure 1 shows a traditional school model

b. ***Alternative Delivery*** – Committee on Development of Science (2000) agree that today's education is viewed as learners constructing new knowledge from previous concepts and beliefs, based on the assumption that learning occur in a physical and psycho-social environment with methods cum strategies that involves use of equipments (like projectors and computer). This style is more concerned with what the learners do, think and understand rather than the teacher's input. Thus, the use of equipments becomes both a focus of study (technology education) and a support for education (educational technology) as seen in figure 2.

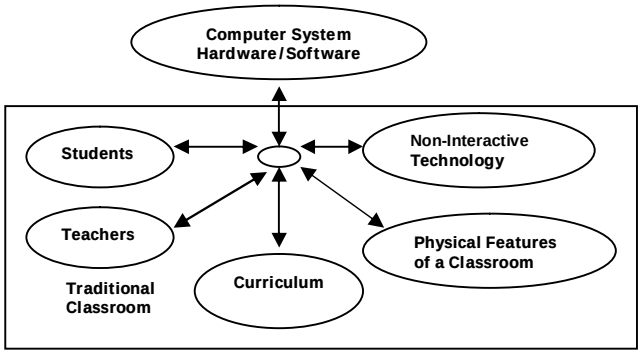

Figure 2 shows a constructivist class model

ICT In Schools: A Theoretical Framework

ICT integration into the education system will bring about great reforms to the teaching/learning process. Educators that advocate for these reforms in schooling especially with via the use and integration of ICT are of the view that the learning process must be more informed by constructivism (Clouse and Nelson, 2000). Many arguments on school reforms involve constructivism that pleads the need of students to develop high thinking skill and the failure of current schooling methods to provide such opportunities (Campione, Brown and Jay, 1990; Loader and Nevile, 1991) – since technologies of the information age are irresistible force on education. A critical factor to ICT integration is *constructivism*, with theories are based on the concept of proximal learning that posits, learning takes place as the learner completes tasks for which support (scaffolding) is initially required and such support may include a tutor, peer or technology (computers) – leading to computer-based learning, where computers are used to maintain the learning environment and to support the learner (Vygotsky, 1978). Technology creates an ideal learning that Glickman (1991) argues have been ignored or failed in its implementation widely, in the past.

It aims to create a learner-centered learning environment with a belief that they learn more from what they do and think rather than from what they are told. If it aims to offer new learning opportunities or improve the way in which current learning activities are implemented – then the overall effectiveness of the learning environment and what is achieved must be a paramount concern to all, not whether they are more effective with or without computers – as the dynamic nature of technology must not overshadow or supercede the enduring nature of learning as well as the solid and ever increasing base of knowledge about learning (Campione et al, 1990; Ojugo et al, 2006).

Constructivism connotes the idea that learning is learner-centered and the learner has the ability to construct knowledge actively as he learns instead of passively assimilated. It emphasizes knowledge as a construction of reality in the learner's mind because knowledge is a dynamic adaptation towards an interpretation of experience. Dewey (1966) views constructivist learning as a one that supports varied interpretations to reality based on knowledge constructed from an experience and context-rich class. Thus, it focuses on knowledge ***construction*** rather than ***consumption*** – as the learner constructs data from experiences and mental beliefs, interpreting events accomplished outside the mind. Thus, we do not describe the world we see, but rather we see the world we describe.

The constructivist environment has tasks of real world relevance, integrated across curriculum to provide appropriate level of difficulty and learner involvement because its instructions are anchored on a real, world context. The learner's ideas and interest drives his ability in the learning process with teachers being flexible as knowledge guides and giver (Strommen and Lincoln, 1992). The setting comprise of socially mediated activities anchored on a learning environment where knowledge is generated based on learner's ability to construct knowledge from his environment. Dougiamas (1998) notes the four constructivist dimensions as ***trivial***, ***radical***, ***social*** and ***cultural***. Thus, the principles of the constructivist learning are as thus:

1. Learning is ***active*** as it consists of meaning construction and constructing system for the meanings.
2. Knowledge construction is ***mental*** – since it happens in the mind of the learner.
3. ***Language*** influences a great deal what we learn.
4. Learning is a social activity associated with connections the learner makes with others.
5. Learning is ***contextual*** – since the 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 to learning – because we cannot comprehend new ideas without having some structure developed from previous knowledge to build on.
8. Learning is not ***instantaneous*** but takes time – as the learner must revisit concepts, reflecting on them and using them as often as possible.

Constructivism: Issues and Challenges

Today's education has been transformed by new technologies – due to the large amount of information available to learners, coupled with the fact that the amount of knowledge in the world continues to double at an increasing quick rate that requires a transformative approach to education. Ojugo et al (2006) notes that studies have shown that a technology rich class will observe the following issues:

a. Shift from whole class to smaller groups
b. Teachers work with weaker students more often rather than focusing attention on brighter students as with the traditional settings as coaching occurs rather than lecture and recitation
c. Students are become actively engaged, cooperative and less competitive
d. Students learn differently rather than simultaneously
e. Integrate visuals and verbal thinking rather than primacy of verbal thinking as in traditional class.

The challenges of a constructivism is that educators, parents and learners are ***suspicious*** of the educational practices as it differs from what they are used. This is attributed to the fact that the constructivist learning removes ***statewide*** assessment because traditional educational model allows tests to be ***aligned***. Learners take ***standardized*** tests, which do not assess ***what*** they are learning and ***standard*** report cards with grades will pose a problem for both teachers and learners as class structure will be more ***fragmented***. Problems abound due to lack of funds and unclear vision to keep this systematic change from occurring as rapid as possible. Teachers charged with these duties of emancipating these students do not have a good understanding of how these technologies work and what amount of information is available to them. This paradigm shift will require staff retraining and their roles be redefined to inform them to think about why they do what they do. Acculturation must also take place in schools even though the process be slow (Ojugo, Aghware and Abala-Odibo, 2007; Vosniadou, 2004).

STM Challenges: A Constructivist Perspective

Oranu (2004) laments that STM education is not taken seriously as it is often misunderstood by educators in Nigeria. To address this, proper values must be placed on the need for STM education to help us attain the ***desired*** growth. We must shun the misconception that STM education (technical subjects) is for those who cannot pursue academic programmes – because we should be aware that most industrialized nations today employed both the help of ***educated*** and ***skilled*** in the growth towards technological development. There is no technological advancement without STM education, which is the bedrock of science and technology. The level of technological advancement in today's Nigeria is a sad reflection of the quality of STM education, which is still receives stigmatization in our educational system – hindering the expected technological progress. Okunzuwa (2005) laments that our technological backwardness is attributed to our fallen educational standard by the different systems practiced overtime.

STM, even with its worldwide recognition still receives poor acceptance by many stakeholders today, in Nigeria. Thus, overcoming its challenges requires producing systems of

international caliber that will help put African trajectories in perspective by comparing them with other experiences in the rest of the world. With the unified objective of STM, some of the challenges:

1. **Nativism:** ***Cultural*** constructivism connotes racism as it distorts the fundamental unity in science in that it represents knowledge as meanings that allow a user convey an idea in a different language – even when *referring* to same objective state. It also believes meaning to be connected with linguistics, while *applied* science views meaning as objective states of nature transcending linguistic boundaries. Cultural constructivism will therefore propose that every spoken language must have its own periodic table for atoms and recreate ***nature*** to suit cultural and linguistic boundaries. Thus, nativism and the empiricism of sciences are too ***parallel*** and may never meet at internationalization and globalization.

2. **Globalization:** The issue of poor globalization in science is often misconstrued as *nativism*. Thus, scientist must ensure unification of science via interaction and exchange of concepts, innovations and skills amongst experts with organization scattered all over the world. It will urge individuals as well as research organizations not to be localized and restricted by culture. Competition to be encouraged and circulation of intelligence must become the rule. 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 (Ojugo et al, 2006).

3. **Territorialism:** The false belief of Africans can produce within a closed circle limited to themselves, a legitimate scientific discourse on the realities of the continent (Abonyi, 2005) – forcing territorialism of knowledge to the fore and making an assumption of cultural constructivism to think that generation of knowledge does not transcend cultural boundaries. Ideas from different cultural perspectives must be encouraged with a conventional consensus due to similarities over their differences – because these similarities by virtue of their many appearances, imprints themselves upon the mind; while individual differences that changes from one case to another, fails. Inventors like Faraday, Newton to mention a few, transcended ethnic boundary – because the same electricity discovered by Faraday and further worked on by Edison, is known to both them and us in Nigeria. Today's educational curriculum and instructional material are being ***territorialized***, like STAN, NARD publications with conferences centered on themes: "You and your environment". But the question is, ***how*** does territorialism in STM meets the challenges of internationalization and globalization in Nigeria in the 21st century?

Curriculum and Educational Technology

Having known what problems and issues like ahead of us with both constructivism and STM, what is the way forward, except to ensure that curriculum becomes more dynamic to adapt to technological changes while retaining the enduring nature of education. Newhouse (2006) notes curriculum to be concerned with what is learner and taught, and how this learning and teaching occurs. These include goals, content, and learning outcomes (skills, knowledge and attitude learners are to demonstrate). The ***how*** of curriculum concerns educational methodology, strategies and media resources and use during the course of study. Educational technology concerns the technology used to express teaching/learning process and as such, they are part of the media used to convey curriculum.
There is a two way relationship between curriculum and educational technology in that: (1) the teacher and other components of the educational system determine what is to be taught and learned,

and based on which – the methodology (including educational technology) to be used is selected. Thus, the technology to be used is determined by the intended curriculum – thereby changing teacher's role, physical settings and general pedagogical views of the educational system, and (2) the advent of new technologies in one case, brings about the addition of new contents to the curriculum and in another, made part of the curriculum's contents obsolete. Thus, it appears the contents of the curriculum are changing to take into account the roles of computer in the society as in figure 2 above.

Rationale for ICT Integration

Before integrating ICT support, we must decide what students, teachers and the school aims to achieve. Teachers must rely on the traditions of education theory, their experiences and knowledge of the situation (like student attributes) to make decisions about what the environment will look like and inputs required in the learning process. Finally, teachers will identify problems with providing the environments and inputs, and tailor the computer and other support to provide solutions. In essence, teachers' judgment and their support structures are relied upon to choose the appropriate strategies. This approach ends with decision for computer support rather than starting with such a decision.

Thus, it is necessary that before beginning the use of ICT in school – though many clamor for ICT integration – but it is far better to develop a rationale, as there is little or no point in providing computers in school if this is not completed. With the availability of computers, it is important teachers do not become engrossed in the machine but rather they should focus on their primary role as *educators*. Teachers need to extend their imagination that as developmental changes in computer occurs, they will achieve their goals – as early computer scientists saw the possibility of computers replacing teachers in schools. However, the picture of students sitting behind computers for much of the day have never occurred in the mainstream schools, and most will not like this feat to be realized (Collis, 1989).

Newhouse (2006) notes that there are three (3) main rationales for ICT integration into schools:

1. **Educational Productivity** – Productivity in economics, is a concept in which output (revenue) by the input (cost). Though difficult to define in this context, since output is not easily measured particularly in monetary terms but output can be viewed as the quantity and quality of learning demonstrated by the student or the learning outcomes as in the formular below.

$$\text{Productivity} = \frac{\text{Output}}{\text{Input}} = \frac{\text{Educational Outcomes}}{\text{Costs}}$$

where Outcome is quantity and quality of student learning and Costs is Teacher and student time, classroom material, equipment etc

To increase productivity, we either increase output so that input is decreased, or we increase both the output and input, and vice-versa. Educational technology influences its outcomes and cost. Thus, if a teacher properly selects the input and output, learning is optimized to show increase in the outcome. Some technologies are more expensive and ICT is relatively expensive to acquire, install and maintain to support users – and this must be compared with its potential outcome. But to consider productivity – this cannot be basis to decide to use a technology as there are situations in which a technology should be used because it solves a problem such that if a part of the curriculum is not completed due to lack of technology, then the associated outcome is zero and productivity is zero.

2. **Technological Literacy** – Newhouse (2006) agrees that fundamentally, computers need to be used to address problems that occur in regular curriculum (not fitted into curriculum). The computer is a problem solving machine that must be adapted to typical school problems such as those concerning student's learning, teacher's instruction, school administration etc. educational technology should be selected on the basis that it has the best feature for implementing the curriculum. Thus, educational technology should be used or not used at all.

3. **Support for Student's Learning** – There are many potential use of computers in the learning process but whatever rationale there is requires much more critical evaluation on the part of the students. We do need to bear in mind of these criteria that must be met on the student's part: (a) the management of high quality educational programmes requires and generates large amount of data. Thus, can teachers effective help student's manage these data? (b) Access to and provision of resource materials linked to teaching and learning, (c) computer literacy.

Impact of ICT at Various Levels

Arguments have been put forward to provide a strong rationale for the use and integration of ICT in schools but the real rationale is whether in practice, it has positive/negative impact to the system. We consider these impacts as thus:

✓ **Impact on Teachers/Pedagogy** – A *teacher* is the key component in a learning environment. There is an assumption that ICT integration will require change for all teachers. While some teachers are at the frontier of this transition, others fear what teaching model will result from such a change. Miller and Olson (1994) note that ICT has not altered curriculum as predicted by some educators due to influence of traditional teaching method and routines of practicing teachers. Collis (1989) note that regardless of ICT potentials, teachers remain instructional ***leaders*** and there is always need for human interaction and motivation. Fullan (1996) stresses that such change is complex and difficult to achieve mostly at classroom level. Some teachers fear to lose their established influence over the values and directions of classroom activity. Thus, it is important to help teachers reflect more on ICT impact on their roles and on that of the learner. Teachers seeking to employ ICT must have in mind the issue of curriculum, ICT implementation in the classroom, student roles, behaviour and materials for learning. Cradler and Bridgforth (2002) notes ICT impact on teachers identified and listed as:

a. The balanced roles they play with a perceived risk of reduced influence
b. Teachers are provided great information access that leads to increased interest in teaching and experimentation
c. Requires more collaboration and communication with teachers, administrators and parents
d. Requires more planning, energy, skills development and knowledge of ICT
e. Provides more engagement time for learners that leads to greater productivity

Thus, its impact on pedagogy can be summarized as strategies that are (a) more learner-centered and active, (b) more cooperative and collaborative, (c) learning based on great information access and its source, (d) develop in learners the understanding and need for interdependence.

✓ **Impact on Students** – ICT supports their learning and provides them with technology literacy, increased technology capability and skills, strong academic emancipation from teachers, increased motivation for learning, improves their achievement in core subjects as measured by tests scores, increases student's engaged learning and interdependence. Thus, allowing them to develop skills

associated with time and resource management, concentration, self-discipline, attention to defined task and ability to follow instructions. A change in role and requirement for new sets of skills to be introduced and supported is carefully done with consideration for students with opposing perception and poor past experiences. Loader (1993) notes that students responds and use ICT in different ways as provision of more flexible access to ICT requires greater personal responsibility which may be lacking in a some students and thus, Rowe (1993) emphasizes the importance of computer literacy and that a student makes the computer part of oneself – and this can be readily accomplished where the user interface is customized by the student and the array of tools available can match the student's need. However, it will mean that every student's computer will be different, making it more difficult for teachers and support personnel to provide technical and operational support to the students – making every student more independent in the use of the computer system.

✓ **Impact to Learning** – ICT aims to embed its support in the learning environment by offering new learning chances and improve overall effectiveness of the learning environment, and allow teachers to rely on their long traditions of educational theory, past experiences and knowledge of the educational situation in order to help them make decisions about what and how the learning environment will look like and what inputs into the learning process is required. Thus, Newhouse (2006) says there is no direct link between use of ICT and student learning, but evidence clearly shows that ICT indirectly has positive impact in its use namely: (a) considerable class-size reduction, (b) increased instructional time to learn, (c) development and use of cross age tutoring programs (d) on the average, learners with automated instructions perform better, (e) automated instructions are more cost effective in improving students' achievement and (f) given the right conditions for access/use, significant gains in student learning were recorded with ICT. These point to the fact that learning is mediated through components of learning environment especially, curriculum (pedagogy and content) as seen in figure 3 below.

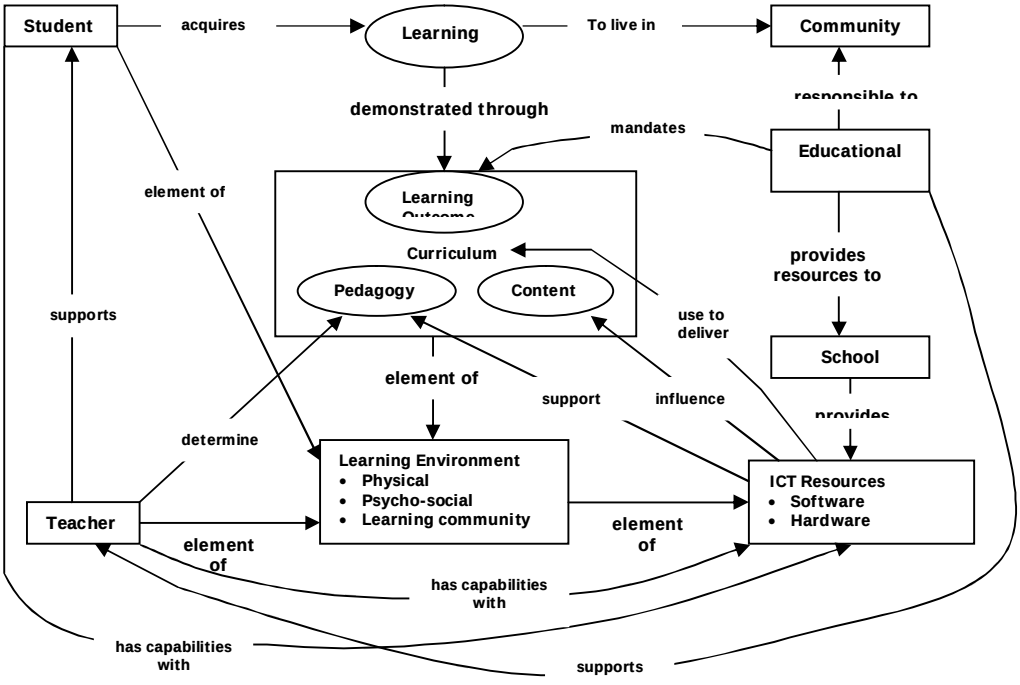

Figure 3 shows the concept map indicating the relationship between the learning environment entities and external entities

✓ **Impact on Curriculum** – With the two-way relationship between ICT and curriculum where ICT is used to assist conveyance of curriculum and at same time change the content of curriculum. Further reports 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 (Cradler and Bridgforth, 2002). The impact of ICT to curriculum can be viewed in terms of (a) declarative knowledge that describes events by specifying properties that characterizes them or knowing that and (b) procedural knowledge that focuses on the processes needed to obtain a result or knowing how. Committee on Development of science (2000) as cited by Becta (2002) notes a dynamic model with interactive multimedia provides visualization and analytic tools that are currently, profoundly changing the nature and inquiry into STM. These changes affect the kind of phenomena considered and the nature of argumentation and acceptance of evidence. Lankshear and Snyder (2000) note that curriculum must remain relevant to societal and workplace needs so that while at school – it is forms the learner's school-based learning that helps them connect in meaningful and motivating ways as they apply it to their workplace – because at some stage this trajectory needs to connect with non-school discourses".

✓ **Impact on Learning Environment** – ICT as a mediator of learning environment in that four distinct implications for using the computer technology in a classroom namely logical programming, graphics and audio output, interactive controls and information processing – as there are many ways ICT has been known to support learners/teachers, increase productivity and improve learning outcomes. The degree to which ICT is applied depends on variables like developmental age, learning environment, the learner's personal attributes and nature of curriculum contents. For both learner and teacher, ICT will allow thorough investigation of real world applications with vast amount of information access as well as tools to analyze and interpret such information so that what can be learned is broadened and deepened (Laferriere and Bracewell, 1999). ICT will also allow active participation and proper assessment of classroom activities. Students' engagement with curriculum will increase and afford them more opportunities to create their own information and represent their own ideas (Riel, 1998). Computer aided programs provide learners with more learning experiences as they interact ***offline*** (with computers) or ***online*** (with others people). Thus in both cases, the student has more influence on learning and activities becomes more responsive to the learner needs to better facilitate the development of the theoretical framework of students, and assist in deeper levels of learning.

✓ **Impact on Educational System** – Schools must provide infrastructure and support for teachers and learners so as to maintain the constructivist-learning environment in which ICT is used. Thus, Brown (2004) highlights seven requirements for ICT use 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 five areas of impact as stressed by Ojugo, Aghware, Okonta, Agbon, Abala-Odibo and Onochie (2008) namely:

a. Provision of infrastructure of hardware and software
b. Provision of curriculum and technical support for teachers
c. School organization, design, policies and practices
d. Schooling, and

e. Management support

Schacter (1999) notes, "The level of effectiveness of educational technology is influenced by the specific student population, software design, educator's role and level of student's access to the technology". Lankshear and Snyder (2000) clearly stress that the critical roles played by teachers, education system must take into account the needs of teachers first – since the problem teachers have with ICT integration is access to adequate infrastructure and support for its implementation. The networking of educational technology resources benefits students, teachers and the school as it facilitates technology learning tasks, gives easy access to software, allows communication variety, reduced equipment cost, increases data processing power, and facilitates management of student's learning (Office of Standards in Education, 2005).

Summary

This study contributes in four broad ways: (1) its outcome gives a full description of individual, group and organizational adoption of technology for teaching and learning across the various schools and educational levels, showing the way it can be implemented (2) it images exemplary practices for teaching, learning and research; and (3) shows evidences linking technology integration, engaged students learning and staff development. Its significance is both theoretical and practical as follows:

a. It increases the understanding/diffusion of ICT innovations as well as the application of its theories and conceptual models in education – showing its potential challenges with the encouraging of widespread adoption of ICT integration for teaching/learning to implement technology outcome curricular across subject areas in schools.
b. It highlights a systematic documentation of adoption pattern and characteristics of administrators and teachers wiling to integrated ICT with the support of network facilities. The result of the investigation shows that the use of shared instrument for access of widespread information by both teachers and students alike based on the scale of engaged student learning and the stages of technology adoption, will form the foundation for the next step in the planning and implementation processes at each school. This information is useful to all stakeholders in educations.
c. This mode of teaching and learning in its best practices provides the much-needed images of how ICT integration will be used efficaciously in education for meaningful students learning outcomes – because such knowledge is useful at organizational and individual level for the staff development in technology integration as well as for further research in such areas.

Recommendations

The recommendations are as follows:

a. Government must develop means to fund ICT integration in our educational system and provide support and infrastructures – knowing that educational reforms do not just mean the provision of ICT equipments.
b. Staff development programs must be organized, and schemes to equip teachers and redirect their focus towards emancipating their students. Such schemes will provide opportunities that will effective support the new ICT teaching/learning process.
c. Educational reforms must be made that to reflect ICT integration into curricular as well as reports/reviews then presented to the government for proper assessment and implementation.

d. School boards and administrator should provide professional development plans and training to aid teachers better understand their new role and what is ***expected*** of them as well as how they can navigate the system as ICT is fully integrated into the school curricular. Also Administrators and teachers alike having gained insight to some of the problems that must arise with this integration, must equip themselves and make decision that will help alleviate these problems as they hold the keys to students success in this new education plan.

Conclusion

Thus, a constructivist class will meet five goals: Independent, Individualized, Interactive, Intuitive and Interdisciplinary. This strategy must be complemented and juxtaposed into the existing educational process, as it will contribute significantly to repositioning teaching/learning as well as provide teachers with the opportunity for active participation with their students to aid meaningful learning. Thus, our curriculum and instructional material must be developed to meet a globalize-educational system with respect to STM development by shunning ***nativism*** and embracing internationalization. Thus, we must devise strategies to de-territorialize knowledge, which in turn will help redefine our educational goals to meet global unification. Constructivist learning gives an outcome that allows for description of individual, group adoption patterns of technology for teaching/learning across disciplines at various school and educational levels.

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