Internet of Things (IOTs) Bridging the Gap in Tertiary Educational Process

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ABSTRACT— Due to the great advancement in technology and its wide usage in the world, it is however important to imbibe great advancement in various sectors of our society. Internet of Things is one of those great inventions and innovation in technology that has come to stay and ease some of our daily activities. IoT in the educational sector is gaining grounds and as such more attention needs to be paid to that regard. This paper explored the key concept of IoT in the educational sector paying attention to how it is bridging the gap in educational process. The study also look at some of the implications of using IoT in education which opens up opportunities for learning. Hence it enables learners to access, extend, transform and share ideas and information in multi-modal communication styles and format. Some of the benefits of IoT includes improving learning skills, enhances mobile learning, helps in easy data collection and analysis. The future of IoT was compared with the present situation in this study. Furthermore, this study also explained the reasons why IoT as a new technology should be adopted in tertiary institutions by using the TAM model and developing a conceptual framework from IoT in education.

To this end, the study advised that more research should be done in this area to improve current educational sector especially the tertiary educational system, which will help improve students’ academic performance.

Keywords — Internet, Internet of Things, Devices, Education and Network

I. INTRODUCTION

The advent of Technology has influenced the pattern of educational packaging and content delivery in tertiary institutions. We live in an era where the wealth of data and the exponential growth in the development of new knowledge is challenging institutions to rethink teaching and learning in a global market. Education and the Internet are explicitly linked to global economic development, innovation in industry, and an engaged, productive society. Education is moving from a knowledge-transfer model to a collaborative, active, self-directed approach that will help students increase their knowledge and develop skills needed to succeed in the “Learning Society.”

Research shows that students learn by being actively engaged in relevant and authentic activities—and technology makes this increasingly possible. Learners are also becoming more adept at using social networks such as YouTube and Facebook to text message; post videos, blogs, and images; and collaborate and socialize regardless of time or place [1]. Furthermore, students in tertiary institutions of learning are now using these identified software applications in their smart phones to either create or interact with content, classrooms are becoming virtual “open” through voice, video, and text-based collaboration, and teachers are now taping into the passion points of the students through the use of this wide range of multimodal resources at their disposal to enhance teaching and learning process within and outside the four walls of the classroom.

Information and Communication Technology (ICT) is regarded as the best technology used for handling information, including multimedia, the internet, and devices such as video, cameras and mobile telephones, with the use of personal computer (PC) or laptop. Smart phones, when attached to the internet can provide access to large quantity of information [2]. As more people adopt new technologies for learning, they will thrive in the emerging world of the Internet of Everything (IoE)—the networked connection of people, process, data, and things.

A. What is The Internet of Things?

Internet of Things (IoT) refers to the ever-growing network of physical objects that feature an IP address for internet connectivity, and the communication that occurs between these objects and other Internet-enabled devices and systems. The Internet of Things extends internet connectivity beyond traditional devices like desktop and laptop computers, smartphones and tablets to a diverse range of devices and everyday things that utilize embedded technology to communicate and interact with the external environment, all via the Internet
Cisco believes that students are already experiencing the Internet of Things (IoT)—the networked connection of physical objects. The Internet of Everything is the next step in the evolution of smart objects—interconnected things in which the line between the physical object and digital information about that object is blurred. IoT focuses only on sensor networks—machines communicating with other machines, and the data created as a result. As things add capabilities (such as context-awareness, increased processing power, and energy independence), and as more people and new information are connected, IoT becomes IoE a network of networks where billions, or even trillions, of connections create unprecedented opportunities and new risks.

The Internet has evolved from connecting people and later videos, photos, and text to more recently physical objects. Using sensors, physical objects can “talk” (transmit data) to each other and even command each other to perform a physical act. As things and people become more connected, such objects will also become part of social networks, much in the same way that people tag photos on Facebook.

In this way, the value of such objects will increase for both research and learning [5]. IoE brings connects people, process, data, and things to make networked connections more relevant and valuable than ever before—turning information into actions that create new capabilities, richer experiences, and unprecedented economic opportunities for businesses, individuals, and countries. The Internet of Things (IoT) era that we have entered is a current force of change that is connecting more and more things to the network, deriving more and more data from the network, and, if we extend the definition to the Internet of Everything (IoE), allowing people, processes, and things to harness that data to improve decision making [6].

II. IOT IN TERTIARY EDUCATION

The Internet of Things (IoT) —which refers to the interconnectivity of internet-aware devices—has transformed tertiary education. With e-learning platforms, teleconferencing, social media chat groups, educative gaming applications, radio frequency identification (RFID) and cloud computing technologies all yielding bigger, better data sets, educational institutions are gaining more visibility into their people and resources. [7] Few educational institutions actively incorporate technology into learning, least of all reach out and connect to each other. And, fewer teachers share data, except for research projects.

Massive adoption of technology in education is required so that the power of IoT can be realized and learning can become more authentic and relevant through engagement beyond the classroom. Educational jurisdictions and institutions can no longer rely solely on their core competences and teacher knowledge. Instead, they must embrace—not prohibit—the devices that learners bring into the classroom and allow students to use them as learning tools to capture intelligence faster and accelerate learning.

The proliferation of mobile devices will also enable educational institutions to collect data to interpret a learner’s behaviors and activities. Used intelligently, such data will result in personalized learning targeted to individual needs, learning styles, and aspirations. There are myriad uses for technology in education, but many are piecemeal and ad hoc with little informed thinking. IoT has the potential to integrate technology with learning in many ways. [1] Higher education programs must ensure that the next generation of engineers understands how to design
and build technological systems that reflect our altered expectations of openness and participation. In the area of computer science, the challenge is in developing new forms of scalable education that accommodate large numbers of students around the world, attract potential students with various interests, and deliver an innovative curriculum that reflects the radical changes in computing technology.

A. Four Pillars of IoE in Education

There are four pillars of IoE in education as highlighted by [8] includes people, process, data and things. This section however explores the impact each pillar has on education and what is needed to support, build, and scale some of the practices currently being planned or adopted.

People: Today, most people connect to the Internet using multiple devices and social networks. It is too soon to predict the channels people will use to connect to the Internet in the future—what is certain is that through such channels, people will be hyper-connected.

The education sector must understand how people connect to the Internet to increase their learning and apply their knowledge as a result. Time to mastery will be key knowledge gained today will be used tomorrow. Those learners who thrive will stay current and ahead of the pack. In the words of author Alvin Toffler,[9] there will also be those who know how to “learn, unlearn, and relearn.” Finding the right people with and from whom to learn will be crucial.

Process: Process plays an important role in how people, data, and things work together to deliver value in the connected world of IoE. With the correct process, connections become relevant and value is added because the right information is delivered to the right person, at the right time, in an appropriate way. Ensuring that young people have access to learning opportunities that meet their needs will make education more efficient, improve time to mastery, and motivate learners. Such opportunities will also increase student retention and the application of new knowledge, which is vital for future success in both work and society.

Much value can be derived from feedback on a student’s performance. For example, a learner studying 10th-grade geography could observe his or her ranking in real time against all learners studying the same level geography. The process could eliminate examinations used to measure and compare learners’ performance and achievement. The model of measurement could be accurate at any moment in time, providing ongoing, targeted, and personalized feedback on what a learner must do to improve his or her understanding and performance.

Data: As things connected to the Internet evolve, they will also become more intelligent, thereby providing more useful information. Rather than just report raw data, connected things will soon send higher-level information back to machines, computers, and people for further evaluation and quicker decision making.

The implications of this in education are enormous. For example, as part of their studies, learners could tag physical objects, collect data about those objects, and then feed that information to other programs for analysis, improving the accuracy of their research. Learners could also access data from research initiatives, monitor programs on oceanography or climate change, or watch animals in their natural habitats via live webcams collect data on their movements through sensors attached to the animals’ bodies. The authenticity of such data will have a huge impact on learners’ interests. Furthermore, collecting data remotely will also help people reduce their carbon footprints through fewer field trips.

Research has shown that access to real-time information and engagement with experts truly impacts learning.

Things: Things are physical items that can be connected to both the Internet and people via sensors. Sensors give things a “voice”: by capturing data, sensors enable things to become context-aware, providing more experiential information to help people and machines make relevant and valuable decisions.

For example, smart sensors are being used today in bridges to monitor temperature, structural integrity, and traffic density in real time. In this way, students can learn physics using their portable devices to collect and observe the bridge at peak traffic times. Capabilities like these have huge implications for learning and the potential to help transform pedagogical practices.

B. A Conceptual Framework for IoT in Education

After considering the four pillars of IoT in education, it is therefore paramount for the research to design an adaptive framework that could stand as the basis for IoT in education. Hence these has led to the development of the conceptual framework for IoT as shown in figure 3 below.
Figure 3: Conceptual Framework for IoT in Education

The above figure reveals the interaction and relationships between People, data, things and process and how they are all linked to IoT through process. Process plays an important role in how people, data, and things work together to deliver value in the connected world of IoE which is its main objective in education. The diagram also shows a double line arrow from people to things and data to things and also from things to process and direct to IoT. This shows that there is a two way relationship between the four pillars of IoT in education which helps students to be able to interact using this new technology.

C. Pervasiveness of IoT in Education Using Technology Acceptance Model (TAM)

TAM theory was developed by Fred Davis in 1989. The model is an information system (consisting of the network of all information and communication technology channels used within an organization) theory based on theories in social psychology, such as the Theory of Reasoned Action (TRA) and the Theory of Planned Behaviour (TPB), the TAM has been validated as a powerful and parsimonious framework to explain users ‘adoption of information technology (IT).

According to TAM, usage of an information system is determined by users ‘intention to use the system, which in turn is determined by users ‘beliefs about the system. There are two kinds of salient beliefs involved: perceived usefulness (PU) and perceived ease of use (PEOU) of the system. The theory stated that, if a user perceives a specific technology as useful, he/she will believe in a positive use-performance relationship. Since effort is a finite resource, a user is likely to accept an application when he/she perceives it as easier to use than another. As a consequence, organizational technology with a high level of PU and PEOU is more likely to induce positive perceptions.

The relation between PU and PEOU is that PU mediates the effect of PEOU on attitude and intended use. In other words while PU has direct impacts on attitude and use, PEOU influences attitudes and use indirectly through PU. User acceptance is defined as —the demonstrable willingness within a user group to employ information and communication technology for the tasks it is designed to support [9].

Figure 4: Illustration of the Technology Acceptance Model [10]

In view of Internet of Things (IoTs) in education, TAM suggests that if users (Lecturers and students) formulate a positive attitude towards the technology when they perceived the technology to be useful and easy to use, then the technology will be adopted [10]. A review of scholarly research on IoTs acceptance and usage in tertiary institutions suggested that TAM has emerged as one of the most influential models in this stream of research. TAM gives deep understanding of importance of theoretical contribution towards IoTs integration and acceptance behaviour in tertiary institutions.

TAM also revealed the factors that influence ones attitudes acceptability or otherwise of a particular technology to include: Perceived usefulness and Perceived ease-of-use. To this end, IoT when applied to tertiary education will stand the test of time going with the postulation of TAM adoption of IoT in tertiary education.
D. Implications of IoT in Educational Process

Education around the world is experiencing major paradigm shifts in educational practices of teaching and learning under the umbrella of ICT enabled learning environment. The world is witnessing spontaneous growth in communication technology, computer network and information technology. Development of new broadband communication services and convergence of telecommunication with computers, which can be said to be IoT, have created numerous possibilities to use a variety of new technology tools for teaching and learning system.

The integration of computers and Internets offers unprecedented opportunities to the education systems which can enhance students and teachers interaction over a wide geographic distance, without the barrier of space, through a meaningful way to achieve the learning objectives. The growth of these network and computer systems, their ease of use, the power and diversity of information transfer allow teachers and students to have access to a world beyond the classroom. It has the potential to transform the nature and process of the learning environment and envision a new learning culture. Interactivity, flexibility and convenience have become the order of the day in the ICT supported environment[11].

IoT opens up opportunities for learning because it enables learners to access, extend, transform and share ideas and information in multi-modal communication styles and format. It helps the learner to share learning resources and spaces, promote learner centered and collaborative learning principles and enhance critical thinking, creative thinking and problem solving skills.

E. Benefits of IoT to Education

The following are the benefits of introducing IoT to the educational sector:

1. Easy Collection of Data and its Analysis for Research Purpose: data are always gathered, tagged and analyzed based on information associated with them; this is done in order to get new findings or development about the objects in question. With the introduction of IoT, this process becomes easier. Once the students set up the process (tagging the item, associating certain data and commends to feed that data to other servers for analysis), they can sit back, collect the data and run it through various programs for their research. Having to go out to the physical object all the time to collect data on different conditions will be a thing of the past. The students will have 24 hour data collection, which will make their research more accurate. [8]

2. Improvement of Learning Skills: introduction of IoT to education improves the skills for learning new things especially. Objects can be touched and information about it be displayed for the students to study. Each object will have a RFID tag attached and when this is placed in front of a RFID reader all the available information about the object will be presented to the student. This can even be used by student willing to learn vocabulary of a foreign language [8].

3. Enhanced Mobile Learning: with the IoT learning can be done anywhere, everywhere. There will be availability of more educational tools. Content can be shared easily amongst student and with teachers.

4. Efficiency and Accuracy: the IoT will reduce error or mistake that are easily committed via minor process, it reduces the risk of impersonation to a reasonable extent as most things that are done manually can be efficiently handled by this technology, e.g. manual taking of attendance, information sharing and so on.

5. Distance Learning: the introduction of IoT into education will encourage or enhance distant learning. Experts in a field that are uneasy to come by become accessible through this means. Students that are home bound either for health reasons, ethnic or religious reasons can fully participate in a classroom activity while away from school [1].

6. Enhanced Assistant for Special Students: learning becomes easier for special students that need support or help to learn. According to [1] [12] IoT will provide minorities and disabled learners access to high-quality learning and peer-to-peer interaction, also student to teacher interaction which will improve their opportunities for greater success.

7. Personalized learning: When schools are equipped with high-speed wireless networks, more and more learning can take place on laptops, tablets and other mobile devices. Data that’s collected from these devices can then be used to offer more personalized lesson plans—all in real time. Not only are these students more engaged, but teachers can then focus their attention on the students who need more face-to-face instruction. Plus, the insight gleaned can be applied in designing future lesson plans.

8. Streamlined assessments: With e-learning platforms, learning assessments can become less manual and time-intensive. Instead of spending hours grading multiple choice tests or feeding Scranton sheets into a machine, teachers can dedicate their time to curriculum planning, one-to-one assistance and other more impactful activities.

9. Enhanced school safety: Campuses can achieve a new level of safety and security, thanks to the IoT’s ability to track objects, students and staff. School buses can be equipped with location-tracking devices, so students, parents and administrators always
know where their bus is. ID cards can ensure only those who are authorized are accessing specific areas on campus. And security guards can use mobile devices to instantly notify teachers, administrators and even local police of a security breach.

10. Smarter resource management: From textbooks to lab equipment to tablets, schools have a lot to keep track of. RFID tags, coupled with an IoT solution, make monitoring these resources seamless. Not only can educators see the location and condition of a classroom tool in real time, but predictive analytics can tell them when it’s time to replace items or expand their inventory, allowing them to be proactive instead of reactive.

F. Factors to Influence the Rapid Enactment of IoT in Education

The following are some of the factors that will enhance wide spread and adoption of internet of things in education:

1. Security: educational institutions are frequent victims of data breach. With research data, student and alumni personal records, health center records, payment information for tuitions, housing, food and books, the data security needs of the education market are widespread. Beyond providing a secure environment for students and faculty, there are many government, industry and state regulations that mandate data security for every type of information stored by educational institutions. This might pose a great threat to IoT security particularly in education. Without assurances, pervasive development of IoT will not take place across educational institutions. Information must be available—yet confidential—when needed, with the owner of the information deciding which people, groups, or organizations may have access to it.

2. Data Integrity: Integrity of data must also be assured, as well as its accuracy, authenticity, timelines, and completeness. Success will be predicated on an “open platform” that allows all partners working together to use the same baseline technologies. Educators will need to work closely with government to ensure the development of IoT in education; at the same time, government must preserve the safety and security of its citizens. Another aspect of data integrity that is becoming increasingly important is related to the use technology in research projects for data collection, storage, analysis, archival, etc. These technologies include electronic instruments or hand-held devices for collecting data, computer systems for storing and sharing data, and software for analyzing data. But the use of technology can create additional integrity concerns that researchers must be prepared to deal with and act responsibly. Adequate training of teachers and students in the application and implications of technology use can help to prevent technology-related integrity violations.

3. Educational Policies: Policies that encourage adoption of technology in the classroom by students and its effective integration into curricula are crucial. Such policies must include sound change management practices among educational institutions to reduce the barriers to technology adoption and increase its scale. Professional development programs for educators should incorporate IoE tools to encourage early adoption and help educators develop innovative methodologies and appropriate pedagogies for the learning environment.

4. School Curriculum: curriculum is a vital part of any school sitting and as such should be taken with outmost concern. It is therefore advisable for school administrators to imbibe IoT into their curriculum design so as to enhance its adoption by creating an environment that will promote its usage.

G. Expected Challenges of IoE in Education

The integration of technologies in educational institutions is still in an embryonic stage, due to teachers variables (attitudes, competence, perceptions, pattern of use), fewer teachers share data, except for research projects. Massive adoption of technology in education is required so that the power of IoT can be realized and learning can become more authentic and relevant through engagement beyond the classroom. Educational jurisdictions and institutions can no longer rely solely on their core competences and teacher knowledge. Instead, they must embrace not prohibit the devices that learners bring into the classroom and allow students to use them as learning tools to capture intelligence faster and accelerate learning.

1. Lack of qualified teachers to teach ICT; The demand for ICT learning has been tremendous and the number of teachers who are trained to teach ICT cannot meet the demand. There are more students willing to be taught computing skills than there are teaches to transfer the skills.

2. Unavailability of resources; Computers are still very expensive especially in developing countries and despite spirited efforts by the government agencies, NGO, corporate organizations and individuals to donate computers to as many schools as possible, there still remains a big percentage of the students unable to purchase computers for their use.

3. Poor electricity; electricity has always been a big challenge in Nigeria, despite all efforts made by the government. Which is affecting
universities and other educational institutions. Consequently the affected schools that fall under this areas are left handicapped and may not be able to offer computer studies.

4. **Poor Internet or slow connectivity:** most schools are not able to connect to the World Wide Web, due to the high costs involved in the connectivity. This is considered as very expensive for a very slow speed.

III. IOT AND THE FUTURE OF EDUCATION

In the nearest future, education will be more user friendly when IoT is introduce to the sector [13], [14]. Reviewed and predicted that classroom will be at everyone’s convenience; there will be sharp contrast between what is obtainable now and what to be expected. Table 1 below show the difference between the current classroom practice and what to expect in the nearest future.

**TABLE 1. Changes in Education through IoT.** Adopted from [14]

<table>
<thead>
<tr>
<th>CURRENT PRACTICE</th>
<th>NEAREST FUTURE WITH IoT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical attendance with teachers</td>
<td>Scale teachers and best quality of instruction-any device. anywhere</td>
</tr>
<tr>
<td>One-time instruction in one location</td>
<td>Scale content recordable and replicable instruction, any time, any venue</td>
</tr>
<tr>
<td>Static, linear content with low control</td>
<td>Learn at your own pace, focus on relevant content only, richer, interactive content</td>
</tr>
<tr>
<td>Costly instructional resources, ‘one size fits all’</td>
<td>Access to crowd-sourced content, ability to customize curriculum</td>
</tr>
<tr>
<td>Ad hoc decision making</td>
<td>Data-driven decision</td>
</tr>
</tbody>
</table>

Below is a chart showing the expected growth of IoT in the nearest future. From the chart we can see that it will take years for IoT potential to be realized.

Figure 3: Internet of Things in the Future [Source: 15]

IV. IOT BRIDGING THE GAP IN EDUCATIONAL PROCESSES

In a technology savvy world where it is very difficult for people to get access to the internet and electronic devices especially in developing countries like ours, IoT will help bridge the gap between the lecturers and their students thereby bringing in full force a new paradigm of teaching and learning known as interactive learning. When interactive learning is practiced in tertiary institutions, it will help improve students’ academic performance [16] it will also bring the students closer to their lecturer. Also distance won’t be a barrier anymore between lecturers and students with the application of IoT in tertiary institutions as this new technology will bridge that digital divide that exist between them. To this end, it is therefore advisable to apply IoT to the educational sector, especially tertiary education as this will bring about more positive results for the students especially and also improve the delivery capabilities of Lecturers.

V. CONCLUSION

In conclusion, there is tremendous value in connecting the unconnected with intelligent networks across education. This paper explored the concept of IoE, its potential impact on making education more relevant, engaging and motivating learners, and enabling faster time to mastery. However, to realize the benefits from connecting people, processes, data, and things, reliable connectivity and continuous access must be guaranteed. Additionally for IoE to be accepted, both policymakers and educators must be well-prepared not only to exploit, but also to understand potential risks involved in its adoption and be ready to promote it.

The study also considered the fact that IoT when applied to educational sector helps to eliminate old teaching methodology by introducing a new paradigm of learning know as interactive or cooperative learning and this new paradigm help to improve the learner ability to assimilate better by improving their academic performance. Furthermore the future of IoE was also discussed as compared to the current situation we have. It is however advised that more research should be done in this area to see how to improve our educational sector especially the tertiary educational system. Problems deterring ICT usage should be addressed such as poor electricity supply, to encourage the frequent use of ICT in the teaching and learning process. And the university administration should allow students use the Internet facilities (Wi-Fi) and some websites can be filtered to reduce abuse and unnecessary wasted of Internet data by students. For further studies, another passionate researcher can pick up from where this work left by looking at critical the negative influence IoT will bring to tertiary education when fully applied and adopted in the nearest future.

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