POTENTIALS OF MOBILE TECHNOLOGIES IN ENHANCING THE EFFECTIVENESS OF INQUIRY-BASED LEARNING APPROACH

Edeh Michael Onyema[1], Udeze Ogechukwu Anthonia[2], Edeh Chinecherem Deborah[3]

1. Lecturer, Dept. of Mathematics and Computer Science, Coal City University, Enugu, Nigeria
2. Admission Officer, Coal City University, Enugu, Nigeria
3. Faculty of Law, Enugu State University of Science and Technology, Nigeria.

* Corresponding Author: Edeh Michael Onyema

Abstract

The quality of teaching technique employed by the teacher basically influence student's interest and learning outcome. In recent times, it has become obvious that the conventional learning pattern can no longer meet the need of digital millennials nor prepare them for the future. This has necessitated the transition from traditional (teacher-centred) approach to inquiry-based (student-centred) approach in order to improve students' skills and enhance productivity in learning. The present study critically examines the potentials of mobile technologies in enhancing the effectiveness of inquiry-based learning approach. The findings show that mobile technologies have the potential to enhance the success of inquiry-based learning method. Indeed, the inquiry process can be more effective if the "Inquirers" can maximize the potential benefits offered by mobile technologies. The study indicates that many students are closely attached to their mobile gadgets such as smartphones, tablets, notebooks and other PDAs, and can easily manipulate it for inquiries, discoveries and innovations. Also, mobile devices often come with fascinating features, apps and functions that motivate learners to connect to the internet, think critically, and to actively engage in authentic and creative learning inquiries, collaborations and discussions. With the aid of mobile devices, students can conduct inquiries (ask questions) via phone calls; text messaging, chat, and e-mails both within and outside the classroom. From the study, it can be inferred that, the use of mobile devices enhance inquiry-based learning; promotes student's inquiry and entrepreneurial spirit, and positive attitude towards learning. Also, mobile devices can inspire students to learn more comprehensively and effectively,

thereby increasing their proficiencies, and preparation for changes; challenges, and a knowledge-based society. Thus, the study concludes that the effectiveness of inquiry-based learning approach in the 21st century can largely be enhanced by mobile technologies.

Keywords:

Inquiry-based Learning, Inquiry-based Teaching, M-Learning, Mobile devices, Smartphone

1. Introduction

The evolution of mobile technologies has increased connectivity, interactivity and productivity in education. The increasing use of technology in education have modified teachers' method from traditional approach that often place them as dispensers of knowledge to a more flexible approach where they act more as facilitators, mentors and motivators to inspire students to participate and learn. Educators now use different mobile platforms to communicate and interact with their students, and also to receive feedbacks from them on assignments and other learning tasks. Students use mobile devices ranging from smartphones, tablets and notebooks to ask questions and generate answers on the go. [1] stated that emerging technologies such as mobile computing and tablet computing has brought tremendous transformational changes to the teaching and learning across the globe. Mobile devices enhance students' involvement and participation in the learning process. It has the advantage of reaching even the most marginalized areas, and the potential to widen access and supplement education in developing areas of the world [2, 3]. By using mobile devices, students can have a more customized learning pace and process, and can receive individual attention and learning guidance when they are distributed in the field [4].

Mobile technologies enhance ubiquitous learning, providing students with the opportunities to access new or stored information on the go. It provides access to services, content instruction and information outside the traditional learning space [5]. Mobile devices have various distinctive features such as individualized interfaces, real-time access to information, context sensitivity, instant communication, and feedback, and these features enhance the effects of certain pedagogies, such as self-directed learning, inquiry learning, or formative assessment [6]. Mobile technologies are effective tools for enhancing students' engagement with their peers and environment. The use of mobile phones in classroom enables students to participate more actively in a learning process, and to engage meaningfully with the teacher both within and outside the school walls [1]. Students can use mobile devices during classes to digitalize teacher's notes and

to video or record his teachings for further listening after classes.

Inquiry-based Learning is an efficient approach for fostering learners' curiosity and motivation, and it help learners to develop their ability to work in complex and unpredictable environments making them more critical thinkers and active learners [7]. Inquiry-based learning aspires to engage students in an authentic scientific discovery process [8]. It has a powerful effect on student's learning growth, and enhances their thinking, analytical, and problem-solving skills. Inquiry-based learning approach has the potential to increase students' level of engagement, collaboration and participation in learning activities. McMaster University in Canada cited in [9] defined inquiry as a form of self-directed learning in which students take more responsibility for: determining what they need to learn, identifying resources and how best to learn from them, using resources and reporting their learning, and assessing their progress in learning [10]. Inquiry-based focuses on telling a particular audience the personal story of the "learning journey," rather than just recounting the facts as in a traditional paper [11]. [12] cited in [13] opined that student inquirers are encouraged to explore new ideas and understandings through personal discoveries and explorations as well as interactions with objects and people in order to enhance inquirers" opportunity to engage in real life activities, situations and real audience.

[14] stated that Inquiry-based Learning has been promoted as a student-centred approach that can strengthen the links between teaching and research. [15] encouraged readers to experiment with Inquiry-based Learning in their courses in the interest of identifying more diverse styles of instructions, and developing a wider understanding of the advantages and disadvantages of the methodology. Inquiry-based learning facilitates learners' interaction with their teacher (facilitator), peers/colleagues, immediate environment, and other variables that directly or indirectly affect their learning. It increases the rate of curiosity among students on how a given problem or task can be solved within themselves without external help. Inquiry-based approach gives learners the opportunity to acquire and share knowledge, and to learn multiple approaches to problem solving.

When students are able to collaborate to provide answers to a given question with little or no supervision, it enhances their confidence and productivity in learning. This can be facilitated by mobile technologies. According to Kevin and Matthew [16], mobile devices are used extensively in the classroom and laboratory to liberate students from the physical confines of the formal classroom, enabling them to work and interact with peers and experts beyond the classroom,

using teacher controlled sites such as class blogs, wikis, and discussion forums. When teachers choose to use an inquiry-based approach, they commit to provide rich experiences that provoke students' thinking and curiosity; to plan carefully-constructed questioning sequences; to manage multiple student investigations at the same time; to continuously assess the progress of each student as they work toward their solution or final product; and to respond in-the moment to students' emerging queries and discoveries [17]. Considering the growing benefits of mobile technologies in education, the present study examines the potentials of mobile technologies in enhancing the effectiveness of inquiry-based learning approach with a view to attract stakeholders' support towards the use of mobile technologies, and inquiry-based approach in classroom.

2. Review of Related Work

Mobile technologies present features and functions that promote inquiry and learning activities. It inspires students to show interest in learning and enhance the achievement of set teaching learning objectives [1]. Mobile devices have become essential tool for discovery and creativity. Inquiry-based approach emphasizes questions and development of strategies to provide answers to the formulated questions. By engaging in inquires, students acquire variety of skills to enhance their adaptability and productivity in a changing world of works. [14] examined the potential of Inquiry-based learning to strengthen the teaching-research nexus by analysing three case studies; a structured inquiry third year endocrinology medicine module, a guided inquiry second year political communication, and an open inquiry third year ecology course. They concluded that "if teachers are aiming for strong links between teaching-research, they should adopt an open, discovery-oriented inquiry based learning approach. [18] carried out a theoretical and empirical review of the effectiveness of inquiry learning method to enhance students' learning outcome. She reported that Inquiry-based learning developed students' intellectual and emotional abilities and enhanced effectiveness of students in learning.

[6] investigated the effects of integrating mobile devices with teaching and learning on students' learning performance. They concluded that mobile devices such as laptops, personal digital assistants, and mobile phones have become a learning tool with great potential in both classrooms and outdoor learning. [4] carried out an inquiry-based mobile learning exploration activity that guides elementary students to learn social science activity with digital support from mobile devices and wireless communications. They concluded that inquiry-based approach with support

from mobile devices is appropriate for social science learning and it has a significant positive effect on students' learning. [19] applied inquiry-based learning strategies to facilitate student-centered learning in Maths education. Their findings show that mobile Inquiry-based Learning engaged students in heterogeneous/mixed ability classes and promoted both team collaboration and competition in learning Maths. Similarly, [20] examined the enablers and constraints to the use of inquiry-based learning in undergraduate education. They found that the enabling factors were teacher attributes-being student centered, reflective but rebellious; course design attributes-questions stimulating learning,, collaborative learning, progressive development of inquiry skills, required student preparation, and institutional attributes.

[21] carried out a comparative study on traditional school field trips, and inquiry-based mobile learning activities with and without mobile devices. They discovered that there was no statistically significant difference between the two teaching methods, but mobile technology support actions relevant to inquiry-based learning. [22] stated that guidance is pivotal to successful inquiry-based learning. Indeed, inquiry-based approach demands that students be mentored and guided by the teacher in order to achieve the objective of the method. Undoubtedly, there are growing studies on the application of mobile technologies, but there seem to be a rarity of literature that focus on its potentials on Inquiry-based learning approach. Consequently, the present study examines the potentials of mobile technologies on the effectiveness of Inquiry-based learning with a view to bridge the gap in literature.

3. Concept of Inquiry-based Learning

Inquiry-based learning is a problem-solving instruction approach that provides opportunity for students to think critically, and formulate solutions to tackle hypothetical or real-life problems. It involves a constructivist approach to education which posits that there are many ways of constructing meaning from the building blocks of knowledge and that imparting the skills of "how to learn" is more important than any particular information being presented [11]. In Inquiry- based approach, students are engaged as individuals or organized in groups to carry out inquiries on a given problem under the guide of a teacher, and thereafter discover solutions to them. Students conduct more enquiries than they do in the traditional classroom, and it entails more interactions than lesson presentations. According to [17], inquiry-based teaching is a pedagogical approach that invites students to explore academic content by posing, investigating, and answering questions. They sated that the technique puts students at the center of the learning,

and much value is placed on the component skills of research as it does on knowledge and understanding of content.

Dewey [23] cited in [24] posited that inquiry-based instruction occurs when an "educator is responsible for a knowledge of individuals and for a knowledge of subject-matter that will enable activities to be selected in which all participate and are the chief carrier of control. According to [25], the inquiry-based instruction is an activity of a teacher and a pupil that is focused on the development of the knowledge, skills and attitudes based on the active and relatively individual cognition of the reality by the pupil who learns on his/her own how to explore and explores. Inquiry-based learning is an educational strategy based on discovering knowledge that fosters active participation and learners' responsibility [26]. [27] stated that inquiry-based learning is a learning approach in which students follow procedures and practices similar to those of professional scientists in order to construct knowledge. For [28] inquiry-based approach is a pedagogy which best enables students to experience the processes of knowledge creation, and the key attributes are learning stimulated by inquiry, a student-centred approach, a move to self-directed learning, and an active approach to learning. It is essentially a question-driven, philosophical approach to teaching that involves active, student-centred learning [15].

Inquiry-based learning is built on the assumption that humans have an innate urge to find their own knowledge [18]. The steady development of technology has increased the application of Inquiry-based method across all levels of education. It has been recognized as an alternative method to promote learners' participation and involvement in the teaching and learning process. Inquiry-based learning has become one of the most popular learning methods in the developed countries such as USA and Canada [13]. Many countries across the world are increasingly embracing Inquiry-based learning approach as part of their educational reforms to equip learners with the necessary skills to think critically and creatively. Dr. Cornelia Brunner cited in Education Development Centre [11] developed a model for the inquiry process as represented in Fig.1 below:

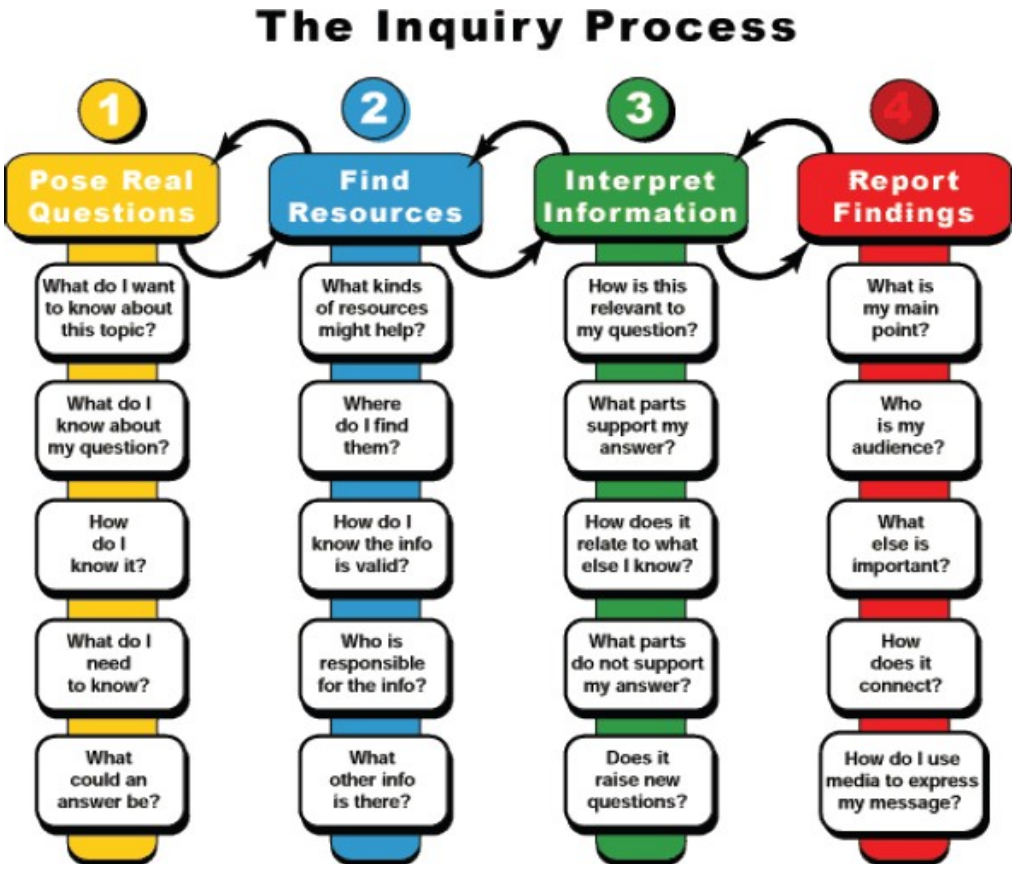

Fig. 1: Dr. Cornelia Brunner's model for Inquiry Process [11].

Similarly, [29] cited in [25] explained the followings as the types of inquiry-based instructions:

i. Confirmative inquiry – the question and method are given to the students, the results are already known. The only purpose of the inquiry is to verify the results by the practice itself.

ii. Structured inquiry – the question and method are told to the students by the teacher, the results are already known. The students form an explanation of the given phenomenon on their basis;

iii. Focused inquiry – the teacher poses a research question, the students create a methodological approach and perform it;

iv. Open inquiry – the students ask the question on their own; they think about the method, they perform a research and form the results [29].

[28] stated that Inquiry-based learning enhance student learning outcome and it can be categorized according to scales- (e.g tasks, course/module/paper, degree), mode (structured, guided, open), and framing (information or discovery-oriented). Inquiry-based approach connects students to practical learning realities. The present study suggests that Inquiry-based learning leads to innovation in learning and increases student's competence in a given field. However, the success of Inquiry-based learning depend on number of factors, including student's interest, time, teacher training, supervision, and availability of infrastructures such as internet connections, that support the integration of Inquiry-based learning method.

4. Advantages of Inquiry-Based Learning Approach

Inquiry-based learning has several advantages associated with it, ranging from academic; social, emotional, psychological and cultural benefits. According to Education Development Center [11] Instructors who adopt an inquiry-based learning approach help students to identify and refine their "real" questions into learning projects or opportunities, and to learn with more freedom while reinforcing and imparting basic skills. The present study summarizes the advantages of inquiry- based learning approach as follows:

i. Equality in Learning: Inquiry-based learning enhances inclusiveness in learning. It accommodates different kinds of learners irrespective of age or diversities, including those with special needs. It provides equal opportunities for learners to participate and contribute in the learning process.

ii. Learning Inspiration: Inquiry-based learning has the tendency to motivate and inspire students to learn more comprehensively and effectively. Since it is student-driven, it encourages students to show more interest and courage in the learning process.

iii. Creativity in Learning: Inquiry-based model affords students the opportunity to take ownership of their own learning. As such they are able to think critically and creatively to formulate questions and answers under the guide of a teacher. It exposes them to wide range of resources and experiences, enabling them to think and create.

iv. Active Learning: Inquiry-based approach promotes practical, active participation and involvement of students in the learning process. Students are at the center of learning, they drive

the process while the teachers act as coach. This can help students to become independent learners.

v. **Problem-solving skills:** Inquiry-based method is a problem-based model, and students are encouraged to formulate hypotheses, conduct inquiries and generate answers. This practice sharpens their cognitive, analytical and problem-solving skills over time, and can help them to prepare for future changes and challenges.

vi. **Concreteness in Learning:** Inquiry-based technique enhances concreteness in learning. Students are able to generate questions and ideas using the language or methods they are familiar with. This makes it easier for them to understand learning concepts better than in the conventional classroom where they often depend solely on teacher's notes or lessons.

vii. **Diagnose of learning Difficulty:** Inquiry-based approach has the potential to assist students with learning difficulties to overcome their learning weaknesses. Their participation multiple inquiries could build their confidence and self-esteem to improve their performances. Inquiry- based pattern is an antidote for learners to develop comprehension, concentration and emotional skills to conquer learning challenges.

viii. **Flexibility in Learning:** Inquiry-based learning is more flexible compared to the rigid traditional teaching method where student's knowledge is mostly underrated, and the teacher act as a "boss" creating fears among students or relegating their input. In contrast, Inquiry-based introduces interactivity, and connectivity rather than memorization or recitation.

ix. **Collaborative Learning:** Inquiry-based approach provide opportunities for students to collaborate on projects, share knowledge and skills, and to learn from each other. It creates the environment for cooperative learning and friendship among students.

x. **Self Discovery:** Through inquiry-based activities, students can discover and rediscover themselves to truly understand their skills and capabilities for future career decisions. They can express interests in some of the areas they are exposed to during the inquiry process.

It is important to note that all of these advantages can easily be facilitated and optimized through the use of various mobile technology devices in the inquiry process.

1. Inquiry-based Learning and Mobile Technologies

Inquiry-based learning is a learning strategy that allows learners to participate fully in the

teaching and learning process in order to acquire the practical and critical skills needed to develop solutions to different problems or task associated with their studies and future works. Inquiry-based learning is a learning pattern that requires students to solve problems through investigation activities that increase their knowledge and skills independently [30]. Inquiry-based learning cannot be successfully implemented in today's educational landscape without the use of technologies such as mobile devices. Mobile technologies are popular among teens and other categories of learners, and they can easily adopt it for learning activities. Advanced mobile devices such as smartphones are very popular among people primarily because they are wireless and portable, and people have become accustomed to them [5].

Mobile technologies are applicable in education for different purposes, ranging from communication, inquiry, in situ data collection, mobile-learning and research. Mobile technologies facilitate education outside the walls of classrooms, enabling teachers to schedule lectures with students at their convenience, and learning to take place on the go. The use of mobile technologies such as smartphones, tablets, notebooks etcetera has the capacity to support Inquiry-based learning activities. With the aid of mobile devices, students can ask questions from the teacher and other respondents based on any subject matter while on transit or from any location either through phone calls, text message or Chat. Many students use mobile technologies to access the internet thereby increasing their level of access, inquiry, and feedback to the teacher. They can use mobile devices to take pictures, record audios, and shoot videos to recall what is being taught, and to make further inquiries on a given lesson. [16] posited that mobile technologies are used by science educators to underpin and reinforce traditional practices of science education (i.e. the status quo) where science is taught as a formal, curriculum-based subject and technology is employed to make teaching and learning more effective and efficient.

[31] cited in [16] compared two case studies to explore the different ways mobile devices can support inquiry learning in semiformal and formal settings. Their findings show that mobile devices with dedicated software supported science students to choose and take personal responsibility for their inquiries without adult help. The present study suggests that, there is a growing bond between mobile technologies and inquiry-based learning technique. Indeed, most inquiries are going mobile, and many individuals and organizations now prefer to conduct inquires through a mobile platform or with the aid of mobile devices. Mobile technologies have the potential to strengthen inquiry-based approach, enhance student-teacher relationship, and improve the quality of teaching and learning.

1. The Concept of Mobile-Learning

The advent of mobile technologies has increased the practice of mobile-learning. Many educators and students now rely on their mobile devices for connection to the internet and access to large volume of educational resources, and daily updates. Mobile-learning has introduced mobility and convenience to education. Mobile-learning is learning by means of wireless technological devices that can be pocketed and utilized wherever the learner's device is able to receive unbroken transmission signals [32]. [33] found that most students used their laptops to write, browse the Internet, make presentations, do homework, or take tests, and teachers made more changes to their teaching methods when they had increased opportunities to use mobile technologies.

[34] cited in [19] stated that mobile-learning has increased access for students who cannot attend schools (e.g., who would not be able to follow courses in a traditional educational setting). [21] stated that mobile-learning has the potential to transform the very nature of learning, and that students learn more through mobile-learning as compared to traditional instruction methods. [16] were of the views that" in both the professional rhetoric and academic literature, mobile-learning is frequently positioned to realize the aspirations of science educators who seek to implement an inquiry-based model of learning within authentic and collaborative contexts.

[5] identified three concepts of mobile learning, these includes mobility of technology; mobility of learning, and mobility of learner. This could be interpreted to mean that mobile-learning brings mobility to education. It breaks the barriers of distance and walls of physical presence in learning. Learners can now engage in sophisticated inquiries from any location, and classes are now being conducted on the go. This widens the space and scope for inquiry-based learning.

1. Inquiry-based Learning and Student Performance

Inquiry-Based Learning enhances the achievement of set educational objectives. Through the involvement of students in the inquiry process, they are able to relate and interact freely with their environment, colleagues and teachers (facilitators) which could brighten their performance overtime. Inquiry-based learning brings about concreteness in learning thereby increasing student's knowledge and understanding of concepts. It empowers students to become innovative problem solvers and independent learners. Students' engagement in the inquiry process facilitates creativity in learning which in turn improve their productivity and academic performance.

Inquiry-Based Learning is student-centred which means students are largely involved, and theycan build their confidence in the process not only to pass examinations on the subject matter, but also to solve other life problems.

Students are better prepared to answer questions, and to express their views on several things being taught. Inquiry-based approach creates a motivational learning atmosphere to inspire diverse learners to achieve their academic goals. It promotes interactivity and inclusiveness in learning, making it possible for all members of the inquiry group to contribute ideas on plausible solutions to a theoretical or practical problem. The result of a study by [35] highlighted some differences in learning outcomes of students who were exposed to group inquiry-based learning model, and those who were taught using the traditional learning approach. His findings show that students who were taught with inquiry-based learning model performed better than those taught with traditional approach. [36] carried out a review of literature on Inquiry-based learning. They discovered that most of the studies reviewed suggests that inquiry-based learning positively impact students' ability to understand core concepts and procedures. An inquiry-based curriculum can increase student achievement and narrow the gap between high- and low-achieving students, and also benefit students with special needs [17].

[24] investigated the effectiveness of inquiry-based instruction in improving the Mathematics and Science achievement of fifth graders in a rural elementary school in South Alabama. Their results show that "there was a significant improvement for many student subgroups when the method of instruction followed inquiry-based techniques. [17] reported of a study of which Middle-school physics students who were taught through inquiry, outperformed high school students who were taught with conventional methods. They stated that an inquiry-based curriculum yielded significant gains in student achievement without sacrificing state curriculum standards. Similarly, [37] investigated the effect of inquiry-based learning using a longitudinal study that followed students over three years in two schools with similar student's performance. His findings show that students who were taught in a school using inquiry-based learning performed better than those who were taught in the school where the conventional learning approach were used. Inquiry-based Learning promotes healthy competitions among learners with each individual or group striving harder to formulate the best possible solution to a problem. It brings the best of students due to their quest for discover answers to formulated questions. It can be a viable tool to diagnose students' learning difficulties, and to improve their academic achievement.

The findings of a study by [38] which examined the "significance of social teamwork to the attainment of success of knowledge retention and learning" shows those learners who engaged in an inquiry-based learning environment had high inclinations to attend to the given task of knowledge learning and retained information at the applicable stage of comprehension. With inquiry-based learning, students are able to enrich their knowledge and skills on problem solving, and their cognitive ability to generate novel ideas. Apparently, mobile technologies can increase significantly the effectiveness of the inquiry-based approach visa-avis the performance of students. Consequently, teachers have to guide the students to harness the educational potentials of mobile devices particularly as it relates to its usage for Inquiry-based Learning.

1. Inquiry-based Teaching Model

Inquiry-based teaching is a student-driven teaching model whereby teachers devise flexible means to facilitate students' learning rather than being a director of knowledge. It is a problem-based learning approach and students are expected to learn the art of solving problems. [39] cited in [36] posited that "Inquiry-based teaching is the art of developing challenging situations in which students are asked to observe and question phenomena; pose explanations of what they observe; devise and conduct experiments in which data are collected to support or contradict their theories; analyze data; draw conclusions from experimental data; design and build models; or any combination of these". Inquiry-based teaching enhances experimentation, and critical thinking. Students spend more time in practical activities than in theoretical classrooms. Teachers act more as facilitators of knowledge, providing guidance and supervision to students rather than being sole holders of knowledge as reflected in the traditional teaching method.

Students are organized in groups, and then assigned different topics to conduct inquiries on it, after which they are required to present their findings to the class for knowledge sharing and teacher's assessment. Comments are made on group or individual presentations, and teachers supervise the session to ensure the students are guided in line with the set teaching objectives. Inquiry-based teaching and learning does not totally eliminate the use of textbooks or the traditional approach but it complements it, and makes it more productive. The teacher plays a pivotal role to ensure the success of inquiry-based teaching via thorough facilitation, mentorship and supervision. He/she has to spend more time with the students, guiding and motivating them as them conduct experiments, practicals and group discussions. It provides opportunities for students to interact with their peers and teachers, and to share and exchange knowledge and ideas. The teacher can easily monitor the progress of learning and identify individual learning

differences. The smooth implementation of inquiry-based teaching method requires teacher's commitment, time and technological tools such as mobile technologies. Therefore, educational institutions have to provide the necessary facilities and technologies to support the transition to Inquiry-based teaching and learning.

1. Challenges of Inquiry-based Learning Approach

The inquiry-based learning approach has a lot of potentials, but it also present some drawbacks which stakeholders must address in order to successfully implement it. These challenges are applicable to institutions, students and teachers. Even though, there seem to be a growing demand for use of inquiry-based learning approach across boards, but the approach is still being hindered by number of factors, ranging from time; poor digital literacy, space, poor internet connections; digital divide, archaic educational policies; resistance to change, and incessant labour strikes that often disrupt academic calendars. These challenges are more pronounced in developing countries where basic learning technologies and other educational infrastructures are seriously lacking. [9] stated that the research on learning styles gives rise to caution, as many students may be uncomfortable with inquiry approaches and thus need adequate support to make the transition. Age can also limit the benefits of inquiry-based process, even though inquiry-based approach does not really have any age limit but it can affect the level of inquiry. Teachers are faced with the problem of switching to a new method of teaching which are far different from the traditional approach that many of them are familiar with. Inquiry-based learning requires even more planning, preparation, and responsiveness from the educator—it's just that the educator's role is different [11].

The inquiry-based learning approach often comes with a wind of change that many traditional-oriented teachers perceive as threatening to their "control" and demanding to their skills, and schedules. The role played by teachers in an inquiry-based learning approach differs from that which they play in a traditional teaching method. Rather than being the sole disseminator of knowledge, teachers facilitate knowledge by helping the students to develop their critical thinking skills, gain valuable practical experiences and guide the procedures in the process. Often times, these roles of teachers in an inquiry-based classroom can be miscomprehended and underappreciated sometimes, because some stakeholders, including parents may not understand the efforts being put in by the teachers to enhance the successful implementation of the technique.

Teachers have to adjust their time, method, content, and even skills to be able to successfully adapt to the changes in the new learning system. . A study by Fleischer [40]

discovered some challenges regarding the use of laptops in classrooms, such as encouraging teachers to change their previous beliefs and teaching methods (e.g., teacher-centered lectures) in response to their students' greater flexibility and autonomy; how to reconcile the conflict between the students' desire for independent study and the need for teachers' guidance; and how to facilitate teachers' competence by designing an appropriate curriculum and teaching models for laptop usage programs. The findings of a study by [20] discovered that the major constraints to Inquiry-based learning were gaining philosophical buy-in to inquiry approaches, supporting transition to inquiry; developing self-reflection skills; and coping with varied assessment products, while departmental and institutional challenge include timetables and room allocations.

Also the use of mobile the use of mobile devices for inquiry-based learning presents some new challenges that teachers have to address for effectiveness. Some of these problems include digital divide, network issues, and functionality of the devices. Subject contents has to be in electronic format, while relevant applications has to be installed in the mobile devices to make it compatible for the new learning approach. Angel and Marcus [7] opined that mobile technology is a suitable support for learning process, but there is a lack of practical strategies for educational practitioners to enact the right balance between enabling agency and supporting the students through the mobile technology. [6] stated that researchers must find the key to integrating mobile devices with instructional strategies and ingeniously match the unique features of mobile devices to the resolution of specific pedagogic challenges. [21] stated that integrating mobile learning activities into education is associated with different costs such as the cost of developing mobile learning applications and systems, and the cost of educating teachers on how these technologies can be integrated into educational activities. They suggested that if mobile learning approaches are to become an effective learning modality, and not merely an ideological hype, the guidance role provided by the teacher needs to be rethought. Norsiah [13] suggested that in order to provide a sound and meaningful learning experience in inquiry-based classroom, teachers must first equip themselves with a sound knowledge of the method. From the foregoing, it is conspicuous that there are constrains that impede both the integration of mobile technologies in inquiry-based approach, and the practice of inquiry-based learning model. However, these challenges do not in any way deplete the enormous benefits that accompany it.

1. Conclusion

The study discusses the prospective of mobile technologies towards the effectiveness of

inquiry-based learning approach. It establishes that mobile technologies have the potentials to become powerful tools to increase the effectiveness of inquiry-based learning approach. Mobile devices such as Smartphones, tablets, notebooks and other PDAs, are increasingly essential for internet access which enhances learner's connectivity, collaborations, in situ data collection and creativity. The study suggests that inquiry-based learning technique can be more convenient, effective and productive, if the inquirers can maximize the potentials offered by mobile technologies. The findings show that several features of mobile devices, couple with their availability, portability and affordability makes them vital tools for inquiry-based learning. As such, teachers can leverage on these benefits to narrow the gap in student's academic performance. Also, educators have to prepare themselves for the transition to inquiry-based teaching and learning in line with the emerging trends in education. For the future, we will examine the effect of mobile technologies on education of persons with disability, and on student-teacher relationship.

5. Recommendations

1. Educators should adopt flexible methodologies to create time for students' engagement and involvement in the teaching and learning process.

2. Teachers should equip themselves with modern and mobile skills to enhance speedy and smooth transition to emerging learning techniques such as inquiry-based teaching and learning approach.

3. Educational institutions should formulate flexible timetables to accommodate the integration of inquiry-based approach in classroom.

4. There should be increase in budget allocation for educational sector to facilitate the provision of critical infrastructures such as more and modern classrooms to enhance flexible learning approach.

5. Teachers should be supported to acquire the digital and professional skills required to manage an inquiry-based classroom.

6. There should be reforms in curriculum to reflect the current pedagogical requirements of 21st century educational system.

References

[1] Edeh, M.O. (2019). Opportunities and Challenges of use of Mobile Phone Technology in Teaching and Learning in Nigeria-A Review. *International Journal of Research in Engineering and Innovation*, 3(6):352-358.http://doi.org/10.36037/IJREI.2019.3601.

[2] Kim, P., Hagashi, T., Carillo, L., Gonzales, I., Makany, T., Lee, B., & Garate, A. (2011). Socioeconomic strata, mobile technology, and education: a comparative analysis. *Educational Technology Research and Development, 59*(4): 456-486.

[3] Song, D., Karimi, A., & Kim, P. (2011). *Toward designing mobile games for visually challenged children*. Paper presented at the IEEE International Conference on e- Education, Entertainment and e-Management, Jakarta, Indonesia.

[4] Shih, J.-L., Chuang, C.-W., & Hwang, G.-J. (2010). An Inquiry-based Mobile Learning Approach to Enhancing Social Science Learning Effectiveness. *Educational Technology & Society*, *13* (4): 50–62.

[5] El-Hussein, M. O. M., & Cronje, J. C. (2010). Defining Mobile Learning in the Higher Education Landscape. *Educational Technology & Society*, *13* (3): 12–21.

[6] Sung, Y.-T; Chang, K.-E., Liu, T.-C. (2016).The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. *Computers & Education*, 94 (2016): 252-275.

[7] Angel, S. and Marcus S. (2017). A review of the Types of mobile activities in mobile inquiry-based learning. Computer and Education, 118: 38-55.Retrieved from Sciencedirect.com/article/pii/so360131517302397.

[8] Padaste, M.; Mario, M; leo, A.S; Ton, D.J; Siswa A.N; Van, R; Ellen, T.K; Constantinos, C.M; Zacharias, C. Z; and Eleftheria, T. (2015). Phases of inquiry-based learning: definitions and the Inquiry circle. *Educational Research Review,* 14: 47-61.

[9] Rachel, S.S. (2012) Experiencing the Process of Knowledge Creation: The Nature and Use of Inquiry-Based Learning in Higher Education. Paper presented at International Colloquium on Practices for Academic Inquiry. University of Otago.

\

[10] McMaster University (2007). What is unique about inquiry courses? Retrieved June 1 2007 from: http://www.mcmaster.ca/cll/inquiry/whats.unique.about.inquiry.htm

[11] Education Development Center Inc. (2016). Inquiry-Based Learning: An Approach to Educating and Inspiring Kids. Retrieved from http://www.youthlearn.org/uploads/inquiry- basedlearning.Pdf

[12] Asselin, M., Branch, J. & Oberg ,D. (Eds). (2003). Achieving information literacy standards for school library programs in Canada. O.N : Canadian School Library Association. (atas talian) http://ednet.edc.gov.ab.calk-12/curriculum.

[13] Noriah, I. (2006). Inquiry Based Learning: A New Approach to Classroom Learning.
English Language Journal, 2 (1): 13-24.

[14] Rachel, S.S. and Rebecca, W. (2010). Can Inquiry-based learning strengthen the links between teaching and disciplinary research? *Studies in higher Edu.,* 35 (6): 723-740.

[15] Rachel, S.S.; Bullard, J.O; Waverly, R; Carolyn, R; and Artimus, K. (2008). Where might sand dunes be on Mars? Engaging students through inquiry-based learning in Geography. *Journal of Geography in Higher education*, 32 (1): 71-86.

[16] Kevin, B. and Matthew, K. (2016). Future Scenarios for Mobile Science Learning. Research in Science Education, 46 (2): 287-308.

[17] Center for Inspired Teaching (2008): Inspired Issue Brief: Inquiry-based Teaching. Washington, DC, 20009. U.S.A. Retrieved from www.inspiredteaching.org.

[18] Vera, S.A. (2016). The Effectiveness of Inquiry Learning Method to Enhance Students' Learning Outcome: A Theoretical and Empirical Review. J. of Education and Practice, 7 (3): 38-42.

[19] Song, D; Kim, P; and Karimi, A. (2012). Inquiry-based Learning Environment Using Mobile Devices in Math Classroom. Paper presented at the Annual meeting of the AECT International convention, Louisville, Kentucky.

[20] Rachel, S.S; Rebecca, W; Julie, B; Billy, O.S, and Tom, A. (2011). Enablers and constraints to the use of Inquiry-based learning in undergraduate education. Teaching in Higher Education, 16 (1): 15-28.

[21] Jalal, N; Teresa, C.P; Chiara, R. and Robert, R. (2014). Learning with or without mobile Devices? A comparison of Traditional school Field trips and Inquiry-based Mobile Learning Activities. Research and Practice in Technology Enhanced Learning, 9 (2): 241-262.

[22] Lazonder, A.W. and Harmsen, R. (2016).Meta-analysis of inquiry-based learning effects of guidance. *Review of Educational Research*, 86 (3):681-718.

[23] Dewey, J. (1938). *Experience and education.* New York, NY: Collier Books.

[24] Joanna, E.T and Jerry, B. (2012). Effectiveness of inquiry based and teacher directed instruction in an Alabama elementary school. *J. of Instructional Pedagogies*, 8: 1-17.

[25] Jiří, D. (2015). The definition of the term "Inquiry-based instruction. *International Journal of Instruction,* 8 (2):69-82.

[26] de Jong, T., & Van Joolingen,W. R. (1998). Scientific discovery learning with computer simulations of conceptual domains. *Review of Educational Research*, 68 (2): 179–202. doi:10.2307/1170753.

[27] Keselman, A. (2003). Supporting inquiry learning by promoting normative understanding of multivariable causality. Journal of Research in Science Teaching, 40, 898–921. doi:10.1002/tea.10115.

[28] Rachel, S.S; Rebecca, W; Julie, B; Billy, O.S, and Tom, A. (2012). Evaluating Students perceptions of learning processes and intended learning outcomes under inquiry approaches. Assessment and Evaluation in Higher Education, 37 (1): 57-72.

[29] Rezba, R. J., Auldridge, T. & Rhea, L. (1999). *Teaching & learning the basic science skills*. Department of Education, Office of elementary and Middle School Instructional Services. Virginia.

[30] Trna, J., Trnova, E and Sibor, J. (2012). Implementation of Inquiry Based Science Education in Science Teacher Training. *Journal of Educational and Instructional Studies*, *2*(4): 199-209.

[31] Jones, A. C., Scanlon, E., & Clough, G. (2013). Mobile learning: Two case studies of supporting inquiry learning in informal and semiformal settings. *Computers & Education*, 61: 21–32.

[32] Attewell, J. & Savill-Smith, C. (2005). *Mobile Learning Anytime Everywhere*, London: Learning and Skills Development Agency.

[33] Bebell, D., & O'Dwyer, L. M. (2010). Educational outcomes and research from 1:1 computing settings. Journal of Technology, Learning, and Assessment, 9, 5e15. Retrieved from http://ejournals.bc.edu/ojs/index.php/jtla/article/view/1606.

[34] Valk, J. H., Rashid, A. T., & Elder, L. (2010). Using mobile phones to improve educational outcomes: An analysis of evidence from Asia. *The International Review of Research in Open and Distance Learning,* 11(1): 117-140.

[35] Abdi, A.,(2014). The Effect of Inquiry-based Learning Method on Students' Academic Achievement in Science Course. *Universal Journal of Educational Research*, 2(1): 37-41

[36] Sharon, F. and David,S. (2013). Inquiry-Based Learning: A Review of the Research Literature. Paper prepared for the Alberta Ministry of Education, June, 2013.

[37] Boaler, J. (1997). Experiencing school mathematics; Teaching styles, sex, and settings. Buckingham, UK: Open University Press.

[38] Hattie, J. (2009). *Visible learning: A synthesis of over 800 Meta-Analysis relating to achievement.* New York, NY: Routledge.

[39] Fleischer, H. (2012). What is our current understanding of one-to-one computer projects: a systematic narrative research review.Educational Research Review, 7, 107e122. http://dx.doi.org/10.1016/j.edurev

[40] Schiller, S. Z. (2009). Practicing learner-centered teaching: Pedagogical Design and Assessment of a second life project. J. of Information Systems Education, 20: 369-381.

AUTHOR BIOGRAPHIES

1st (lead) Author

Edeh Michael Onyema is a lecturer of Computer Science at Coal City University, Nigeria. He is currently a doctorate student at Ebonyi State University, Nigeria. He earned a masters degree in Computer Science Education at Tai Solarin University of Education (2017). He has taught Computer Science courses to students and teachers in different higher institutions in Nigeria, and has facilitated multiple professional development programmes for students and youths including members of the National Youth Service Corps (NYSC) Nigeria. His research interest includes learning technologies, inquiry-based teaching, and IT Security.

2nd Author

Udeze Ogechukwu Anthonia is currently the admission Officer at Coal City University, Nigeria. She has a degree in Chemistry Education, and masters of Education in Chemistry in view at Enugu State University of Science and Technology, Nigeria. She has taught Chemistry at African Thinkers Community of Inquiry College of Education, Nigeria. Her research interests include: Food Chemistry, Inquiry-based teaching, and Collaborative Learning.

Edeh Chinecherem Deborah is a Lawyer. She earned a degree in Law at Enugu State University of Science and Technology (2018), and a degree of Barrister at Law (BL) at the Nigerian Law School (2019). She is a legal practitioner and an educator. Her research interest includes Taxation Law, Criminal law and Legal Education.