



Impact of Artificial Intelligence in teaching and learning Sciences

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Abstract

The study provided an insight on the need for the use of AI in the pedagogy of sciences. The need for the study is to address the global challenges encountered by teachers and students in selecting and incorporating technologies appropriate in the teaching and learning of sciences in primary, secondary and tertiary institutions of learning. The study listed and provided an insight on basic packages of Artificial Intelligence such as Mathway, GeoGebra, ChemDraw, Chem21labs, LabXchange, BioLab, etc, that promotes easy teaching and learning of Sciences in most parts of the world. The Mathway was noted as a package that enables students solve problems in mathematics with little or no assistance by the teacher and likewise the GeoGebra was also noted as a learning platform that uses AI to offer feedback and assessment on learning. The study also listed other AI supporting packages that are used for teaching and learning Chemistry, Physics, Biology and other science subjects or courses. The study further suggested that Science teachers at all levels of learning should be introduced to various forms of technologies that AI tools used in the teaching and learning sciences.

Keywords: Artificial Intelligence, Pedagogy, Sciences; Mathematics, Physics, Chemistry and Biology

Introduction

AI is an acronym that stands for Artificial Intelligence. AI refers to the ability of Machines to perform or carryout tasks that typically require human intelligence. It uses algorithms, data, and computational power to follow human's steps through programming (Asuquo, 2018). The introduction of AI into education and pedagogy has significantly increased excitement and fun in both learners and teachers, thereby upgrading the gains of teaching and learning. According to (Nelson,2024), the introduction of AI into education mostly in the pedagogical stage of learning has significantly boosted the excitement level of teachers thereby increasing the gains of learning (learning outcome).

For teachers, AI maybe lucratively used for administrative purposes, lesson planning, lesson delivery/presentation, evaluation of learning gains, scoring, analysis and decision making. Administrative activities such as record keeping and decision making require high-level technology for quality and efficiency's sake. The introduction of Artificial Intelligence on this stage enables the sole administrator

to promptly make quality decisions for the institution. Lesson preparation and presentation also crucially requires the adoption of artificial intelligence in order to boost the speed and ensure quality research before going to the classroom. Formative assessment of students before and during the presentation and Summative evaluations after lesson delivery can efficiently be managed through the adoption of Artificial Intelligence (Lara,2024).

As an incredibly fulfilling profession, teaching requires so many responsibilities before classroom presentation. Before appearing in a regular classroom for lesson presentation, a teacher is required to plan his lessons, create assignments, interact with parents, prepare scoring modalities for assignments and other forms of assessment to be given and prepare modalities and tools for analysis of performance (Esu, 2017). The ability to store and analyze students' data with the help of AI has created new possibilities for the academic community, scientific researchers and biotech industry. All these can best be handled through the adoption of Artificial Intelligence (Lara, 2024).

Significance of the study

The study will be beneficial to Students, teachers, school administrative heads, policy makers and the ministry of education by providing new teaching and learning strategies which will promote excitement, motivation and improved attitude towards teaching and learning. The study will also serve as a guiding tool to school heads and policy makers by providing an insight to new and modern teaching methods that will be interesting to learners and improve the gains of teaching and learning in Nigeria and across world.

How AI can be used in teaching mathematics

The main contribution of AI to Mathematics education is to provide concepts, methods and tools for design of flexible and relevant computer based system for teaching and learning purposes which are achievable through the use of AI assisted software in ICT devices and technologies such as Laptops, Desktops, Mobile Phones, IPad and many others, Nicholas Balacheff, (1993). AI packages used in mathematics education such as GeoGebra, Mathsway, Photomaths and many others requires certain forms of Technologies for their functioning and utilization. Most AI-powered software are functional in Android, Microsoft and others which are powered by laptops, Desktops, Handsets, IPad and other gadgets (Asuquo, 2018). A typical example of AI supported software is the GeoGebra which is widely used in mathematics teaching and learning by Teachers and Students.

How GeoGebra can be used in teaching Mathematics

GeoGebra is a mathematics teaching software that offers methods for learners to access algebraic transformation in an understandable way. The tool enables students and pupils to build expertise by offering solutions to problems in Algebra and Linear equation. As an advantage to teachers and students in the use and practice of GeoGebra, it gives room to learners for selves' interaction and build fluency with Algebraic transformations which makes the teacher's task easier in the classroom. It also gives adaptive hints and In-the-Moment feedback to teachers and students to explore different solution paths and give comprehensive help and guidance which is focused on improving students understanding of basic concepts.

GeoGebra offers products that are broadly categorized into Apps and Resources, which can be

accessed through GeoGebra website (www.geogebra.org). The GeoGebra apps are used in the Pedagogy of Mathematics, Physics, Computer Sciences, and Chemistry classes. The Classic App for instance which was later succeeded by the GeoGebra Calculator Suit is a good example of GeoGebra APP which is employed in the classroom till date.

The GeoGebra maths resources are frequently used in solving problems in major mathematics topics such as Algebra, Geometry, Measurement, Number sense, Operation, Probability, and Statistics. In Algebra, it helps in the learning and practice of identifying and generating numerical and geometric patterns and enhanced pattern recognition skills with interactive resources such as; giving direction in generating numerical and geometric patterns, correction of errors in patterns and interpreting features and giving direction for the completion of number pattern by addition and subtraction.

Benefits of GeoGebra in Mathematics Pedagogy

As an instructional tool, the use of GeoGebra by mathematics teachers in the Pedagogy of Mathematics goes along with so many benefits because it is designed by teachers who actually knows how to best offer help and provide guidance to mathematics students. This enables the programme to provide fast and give accurate feedback to the school and society through instant assessment of learning outcome. GeoGebra provides an online interface for solving step by step mathematics with notable speed and proficiency. The time spent by students in trial error is minimized by using GeoGebra for teaching mathematics at all levels of learning. Results are instantly given step by step which enables students outline their errors as fast as possible.

The use of GeoGebra for teaching mathematics provide a learning space for students to explore different solution pathways and solve problems in different ways with little or no support by teachers. Elements in the practice of GeoGebra gives room for learners to interact and build Mathematics fluency mostly in Algebraic transformation and other mathematical concepts.

It also gives clarity whether what a user is trying to work on is following the right step or not thereby making a time saving approach for the user's which help to save distracting and demotivating users. Multiple trials and attempts to solve a given problem in Mathematics using the traditional methods of Paper and

book or Marker and Board approach most often leads to repeated failure, mostly among learners and teachers in practice which may result to interest lost or lack of motivation to continue. If not properly counselled, such learners with repeated failure may suffer loss of confidence in attempting Mathematics problems.

Demerits of GeoGebra in Mathematics Pedagogy

Garba (2024) in a study on the issues and challenges in the use of GeoGebra in teaching and learning Mathematics in Secondary Schools in Makurdi Metropolis identified numerous issues affecting the adoption of GeoGebra in teaching and learning by both teachers and students to include; Lack of computers, Inadequate Manpower, Poor Power supply, Lack of software and many others.

Most schools in Nigeria are still struggling to get out of the use of Chalk and Blackboard teaching resources due to funding issues. Computers are expensive and mandating students or schools to procure them maybe impossible due to variations in financial status, and willingness of parents which can also be traced to literacy statuses. The use of GeoGebra requires numerous computers for general access of teachers and students which demands can only be met by Government or top elites in various schools or communities.

Computer requires steady power supply, lack of electricity and high cost of petroleum products make it difficult to provide steady power supply in schools. The use of GeoGebra for teaching requires planning ahead of time by teachers to develop programs that will suit the required audience.

In areas with the needed resources for teaching and learning with the use of GeoGebra, manpower factor may be another barrier that can affect the process. Using GeoGebra software requires fair knowledge of computer in both programming and presentation. For a teacher to develop a mathematics program in GeoGebra, such teacher must be knowledgeable in Programming or will employ an expert in programming which will be too expensive and lead to delay in lesson preparation, thereby leading to inefficient planning.

Availability of GeoGebra software in school can also be a demerit of it use. Many schools may not have access to such software and resources. Its use may therefore be impossible since its availability is defeated.

Other AI Software use in teaching mathematics

Apart from GeoGebra, there are many other AI packages that supports the smooth teaching of mathematics in nursery, Primary, Secondary and Tertiary levels of learning. These packages have their own features which makes them unique in various ways with all geared towards effective teaching and learning of Mathematics. This Packages include; Mathsway, Photomaths, Khan Academics Maths.

Mathsway: Mathsway is an AI mathematics problem solver, it answers all mathematics questions pertaining Basic Maths, Calculus, Trigonometry etc. it is a free math problem solver.

Photomaths: It is an AI application that solve mathematics problems by just sharing a photo of the problem on the application. It gives a step by step solution of the solution to the student or teacher.

Khan Academy Maths: Khan Academy is a non-profit online group that provide free world class education for anyone, anywhere. Their interactive practice of problem solving, articles, and videos helps students to succeed in mathematics and other subjects.

The use of AI in teaching Physics

Edidiong Enyeneokpon and Jude Nicholas (2022) in a study on AI Adoption in the Teaching and Learning of Physics among Senior Secondary School teachers in Ibadan North discovered that, teachers' opinion was more positive on the adoption of AI in teaching and learning Physics in the area. Further findings in the study predicted teachers' readiness to incorporate AI in the pedagogy of Physics in the area. The adoption of AI in teaching and learning Physics have several backings for safe landing if practiced. AI packages such as PhET Simulation, OpenSource Physics, Physics Classroom and LabXchange were noted in the study to be useful AI tools for teaching and learning Physics.

Over view of AI packages that are used for teaching and learning Physics

PhET Simulation: It is a non-profit educational resource project that creates and host necessary explanations in Physics and other science subjects. It was founded by Laureate Carl Wieman in 2002, with the vision of improving how Sciences is taught in Schools and Colleges.

Open Source Physics (OSP)

The Open Source Physics was sponsored by the National Science Foundation and Davidson College. Its

mission was to spread the use of open source codes Libraries to take care of heavy concepts lifted in Physics such as: Plotting and Drawing, Differential equation solvers, exporting to animated, etc tools and compiled simulations (J. Bryan, 2004).

Physics Classroom: The physics classroom is an online platform that serves students and teachers free online learning resources for teaching and learning of physics and its concepts.

The use of GeoGebra in teaching Chemistry

As a basic subject in sciences, chemistry is an essential subject in Nigerian school curriculum in senior secondary schools that gives students fundamental awareness of matter' composition and behavior. Just as the pedagogy in other subjects, the traditional methods of teaching and learning Chemistry by teachers and students is centered on teacher and students' utilization of printed textbooks, tables, Laboratory experiments, and classroom interaction between teachers and their students (Kizito and Hassan, 2024).

However, Artificial Intelligence has birthed useful tools and reliable resources that are adding value and serving as Chemistry pedagogical transformer. The traditional teaching approach of chemistry left the subject in a boring and hard to learn state, even though it was largely patronized by large number of students in both Secondary and tertiary institutions of learning. The introduction of AI in the education process have given break through to challenging concepts and topics in the teaching of Chemistry by using AI algorithms to give permanent and faster solutions to problems the traditional approach could not solve (Kizito and Hassan, 2022).

Another relevant point for the introduction of Artificial Intelligence is that it offers support to the teaching and learning Chemistry by providing online learning Modulus and resources such as Textbooks and tables for teachers and students to utilize. It also provides user friendly online learning environment for teachers to interact with students (Podolefsky and Pekin, 2012). The adventure of AI, brought a rebirth of up to date learning materials as the traditional methods of teaching gave room for stressful or no modification of instructional materials. Teachers prepare their lesson notes on stressful background, opening course or subject textbooks and such lesson note will end up becoming a generational teaching guide giving room for little or no modification in teaching subsequent classes that will emerge. AI has brought a fruitful foundation

for teachers and emerging teachers to update and review their notes with computers and smart phones just in few minutes.

Podolefsky and Pekin (2012) listed some of the AI packages that facilitate resourceful Chemistry education to include; PhET, Interactive Simulation, Labstar, Chem collective etc.

PhET and the teaching of Chemistry

According to Kizito and Hassan (2024), several studies have demonstrated the positive impact of PhET simulations on students understanding of Chemistry concepts. A study carried out by Salame and Makki (2021) amongst others opined that PhET simulation is an academically lucrative package for teaching and learning Chemistry because it helps in increasing students understanding of Chemistry concepts. In conclusion of the study, Hassan and Kizito stated that PhET does not only influence students' performance in understanding chemistry concepts but it also motivates teachers to diligently perform their tasks in the classroom. Chemistry concepts teaching and learning such as Gas Laws, Equilibrium of Chemicals, and Electrochemistry have been effectively improved as the PhET is applied in their teaching.

PhET and Gas Law: The nature of gasses is different to understand by students because of its abstract form. PhET provides virtual laboratories for students to learn such concepts even without the teachers' presence.

PhET and Equilibrium of Chemicals: PhET offers dynamic representations of chemical equilibrium process which allows students to investigate how the concentrations, temperature, and pressure affects the equilibrium position and rates of forward and revers reactions (Perkins and Kessy 2012). According to Kizito and Hassan, Chemical substance such as "reactants, products and leftovers" and "equilibrium constants" enable students to manipulate reaction conditions and observe changes in reactions kinetic and equilibrium concentrations. Students develop in depth knowledge from their interactive experimentation into the factors that influences chemical equilibrium (Rahmawatti and Hartano, 2022) in (Kizito and Hassan, 2024).

PhET and Electrochemistry: Concepts in electrochemistry such as redox reactions and electrochemical cells can be difficult to grasp without visual aids. With the aid of PhET simulations like "Electrolyte solutions" and "Galvanic cells", interactive

models are provided for students to explore the flow of electrons, the movement of ions, and the principles underlying electrochemical process (Pekin, Hartano and Rahmawatti, 2024). The use of PhET will offer students the opportunity to manipulate virtual cells and also investigate factors affecting cell potentials, electroanalysis and the production of electrical energy from Chemical reactions.

Other AI packages for teaching Chemistry

ChemDraw: ChemDraw is a molecule editor first developed in 1985, by Selena Evans, David A. Evans and Stewart Rubenstein. It was later sold to PerkinEkmer in 2011. The package is part of Chem office suite programs and is available for Macintosh and Microsoft Office. More packages are; ChemDoodle, Molecular, workbench, Chem21Labs, etc.

The use of AI in teaching Biology.

Muhmmmed Usak (2024) in the journal of Baltic Science Education defined AI in Biology as the deployment of AI in sections of study that helps learners and researcher in Biological sciences. He discovered in the study that AI gives significant meaning towards the improvement of Biology education. It gives a significant meaning towards the improvement of research and expansion of knowledge on Biology concepts. AI technologies developed for Biology instruction enables users to assimilate data across the sub- disciplinary domains which forms the basis of constructiveness of the comprehensive prediction means and assisting targeted and untargeted discoveries.

Incorporation of AI in Biology education has influenced the teaching and learning of Biology in numerous ways, thereby making the subject matter pleasurable to learners through online simulation and mentorship (Hassoun, 2021). Phones, laptops and other AI supported gadgets are gaining popularity in secondary and tertiary schools. Introducing AI with proper guidance by teachers will add meaning to education of scientific and biological concepts. Although, amidst the gains, improper follow up by parents and teachers can make adoption of AI a distractive tool to Biology education. AI has the potential to make Biology education more engaging, personalized and affective by providing students with interactive simulations and personalized learning process, with necessary tools required to promote the affection for Biology with interactive simulations of

Biological concepts. Another efficient use of Artificial intelligence in teaching and learning Biology is distance education or learning. Distance education has benefited tremendously from the introduction of AI to the education industry (Fatima et al 2012). The wide spread of Covid 19 in the world that led to closure of schools and other places birthed drastic patronage of AI packages in Biology education. During that period, the safest form of education was online because it gave no room for physical meeting and interactions as businesses, schools, markets and other public places were shut down for some months.

Summary

The study provided an insight on the need for the use of AI in pedagogy of sciences. The need for the study was to address the global challenges encountered by teachers and students in selecting and incorporating technologies appropriate in the teaching and learning of sciences in primary, secondary and tertiary institutions of learning. In order to give direction to the study, four research questions were formulated to guide the study based on four basic advanced science subjects which include; Mathematics, Physics, Chemistry and Biology. An intensive review was made in the study according on the research questions. The study further listed and provided an insight on basic packages of Artificial Intelligence such as Mathway, GeoGebra, ChemDraw, Chem21labs, LabXchange, BioLab, etc that can promote easy teaching and learning of Sciences. It is therefore suggested that Science teachers at all levels of learning should be introduced to various forms of technologies that supports AI tools used in the teaching.

Conclusion

Incorporating Artificial Intelligence in the pedagogy of sciences have significantly influenced the quality of instructions delivered by teachers, thereby promoting the gains of teaching and learning in schools. The adoption of AI tools such as; GeoGebra, Mathway, ChemDraw, PhotoMaths, etc have positively added to the gains of teaching mathematics, Physics Chemistry and Biology. The use of AI tools in teaching and learning sciences have made science subjects like mathematics less challenging and more interesting to teach and to comprehend by teachers and students who are the sole actors in the teaching and learning process.



Recommendations

Based on the review, the following recommendations are made;

1. Science teachers at all levels of learning should be introduced to various forms of technologies that supports AI tools used in the teaching and learning of Sciences.
2. Government in collaboration with school heads, and proprietors should organize compulsory training for Science teachers ranging from primary, secondary and tertiary levels of learning in other to equip them with the required skills that will help them handle ICT tools that supports AI software.
3. All functioning schools, both private and public should be mandated to purchase ICT tools that supports AI assisted software and such tools should be made accessible by both students and teachers in the institution.
4. Government should have proper inventory of all devices that are purchased in each school and adopt disciplinary measures to guide against abuse or theft of any of the devices and same should also be applicable to private schools and institutions.

Energy: Contemporary issues in Technology and Teacher Education

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