

Digital Pedagogy in Science Education for Sustainable Development

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Abstract

Digital pedagogy is essential now as the entire world moves towards digitalization in all fields. Technology has significantly influenced learning and resulted in the development of digital pedagogy, which has become a vital part of today's world. This paper focus on digital pedagogy in science classroom instruction for sustainable development Science education for sustainable development enables individuals to acquire the knowledge, skills, attitudes, and values necessary. Science education for sustainable development incorporates key issues such as climate change, poverty reduction, and biodiversity into teaching and learning etc. Achieving common goals and shared values for sustainability become challenging to achieve Until rapid advancements in data innovation and information technology, digital learning, and worldwide access to data, information communication technologies (ICT) and development of self-organized technology-driven networks. In this regard, 'Education for Sustainable Development (ESD)' bridges the gap between the traditional and contemporary era that receives global acceptance and global reach. However, the development of digital pedagogy with the influence of ICT platforms can take a huge step towards transforming both science educators and learners. Therefore, creative pedagogy, virtual learning in any place and any time concept are speeding up learning and teaching. It has been observed that many factors, there are challenges in creating capable digital pedagogy for sustainable national development. Thus, as long as teachers are adaptable to digital pedagogy, it can serve learners and create bonding with technology for sustainable development.

Keywords: Digital learning, Innovative pedagogy, Science Classroom, Sustainable development

Introduction

Education is a fundamental human right and crucial for individual and societal well-being. Education empowers individuals to navigate life's challenges. It lies at the heart of promoting behavioural change in man, and has been identified as an instrument for socio-economic, cultural, political development and transformation (Maclean, 2018). Education provides deep knowledge and understanding, advancing society in various fields. The economic transformation requires substantial re-organisation of the economy, adoption of new technologies and promoting sustainable patterns of consumption and production, protecting efficient management of human and material resources (Enrico & Lingeberg, 2015). The world has transformed into a global village through interconnectedness, linking groups, communities, and nations, thus eliminating distance and communication barriers. The present generation is known to be information era propelled by recent development in information and communication

technology which permeates all spheres of human endeavours. Human activities in this era are rapidly shifting to electronic formats. The increasing need for effectiveness, efficiency and continuity, compared with the variety of expectations from man in various disciplines, to function appropriately in the society has become imperative that information and communication technology be employed in teaching and learning for sustainable national development.

Science Education

Science education deals with sharing of science content and process with individuals who are not considered traditionally to be member of the scientific community; the individuals could be students, farmers, market women or a whole community. Science education in Nigeria concentrates on the teaching of science concepts, method of teaching and addressing misconceptions held by learners regarding science concepts. Science education in Nigeria focuses on teaching science concepts, instructional methods, and addressing misconceptions held by learners. Science education is particularly important in everyday life because, there is not one aspect of daily life that science had not touched. It generates knowledge through discoveries and equips the learners with the required skills with which to make life easier than has ever been (Doris & Justin, 2012). Excellence in science education embodies the idea that all students can achieve understanding of science if they are given the opportunity. Science education takes more into consideration what students should understand and be able to do and the manner in which students will achieve those outcomes. Students will achieve understanding in different ways and at different depths as they answer questions about the natural world.

According to Juma and Yee – Cheong (2015), a nation's ability to solve problems and initiate sustainable economic growth is strictly dependent on its capabilities in science, technology and innovation. Science and technology linked to economic growth determine the ability to provide social amenities and adequate infrastructure. Science, technology and innovation have potentials in addressing the challenges associated with poverty and hunger elimination by creating job opportunity, empowering youth with vocational or entrepreneurship skills (Orkaa & kwaghbo, 2011). Science education is viewed by Pember and Humbe (2013), as a process of teaching or training especially in school to improve one's knowledge about the environment and to develop one's skill of systematic inquiry as well as national attitudinal characteristics.

Relevance of Science Education in National Development

National Development is a multi-step concept which has become a slogan in the past decade (Chesterman, 2014). The concept of National Development lacks a scientific foundation but consists of a number of useful and practical steps after a violent conflict has been ended. There is wide-spread agreement in literature that conflicts pass through numerous stages of different intensity. Constructing an ideal conflict life-cycle, a conflict begins with tension, escalation, crisis, instability etc. It ends with resolution, transformation, reconciliation, reconstruction as reported by (Doris & Justin, 2012). National Development is a comprehensive approach, which is usually intensified after the decision to end a conflict. It could refer to the rehabilitation and reconstruction of infrastructure and security forces, the facilitation of the transfer of power from the interim authority to an indigenous government (Schmidt, 2013). In a broader view, National Development is a strategic task which might cover the following:

1. The support for modern forces within an entity
2. The creation of a certain educational level
3. The promotion of women
4. The improvement of societal role of women
5. The support for free and fair elections
6. A peaceful transformational change from inside

Key features or facets of National Development are:

- a. Security policy (e.g., demilitarization and reintegration of combatants; reformation of the armed forces; peaceful conflict resolution; redefinition of civil-military relations; reconstruction of social services, regulations concerning war criminals and crime against humanity, reconstruction of the law system and law enforcement etc).
- b. Educational policy (a sustainable policy on education, provision of quality education in all spheres of the educational sector with set goals, aims and objectives, provision and involvement in technical and vocational education etc)
- c. Social policy and economy (transformation of a war economy into a sustainable peace time economy; creation of jobs, reintegration and job provision etc)
- d. Psychology (restoration of neighbourly trust and social networks; reintegration of refugees and traumatized people etc).

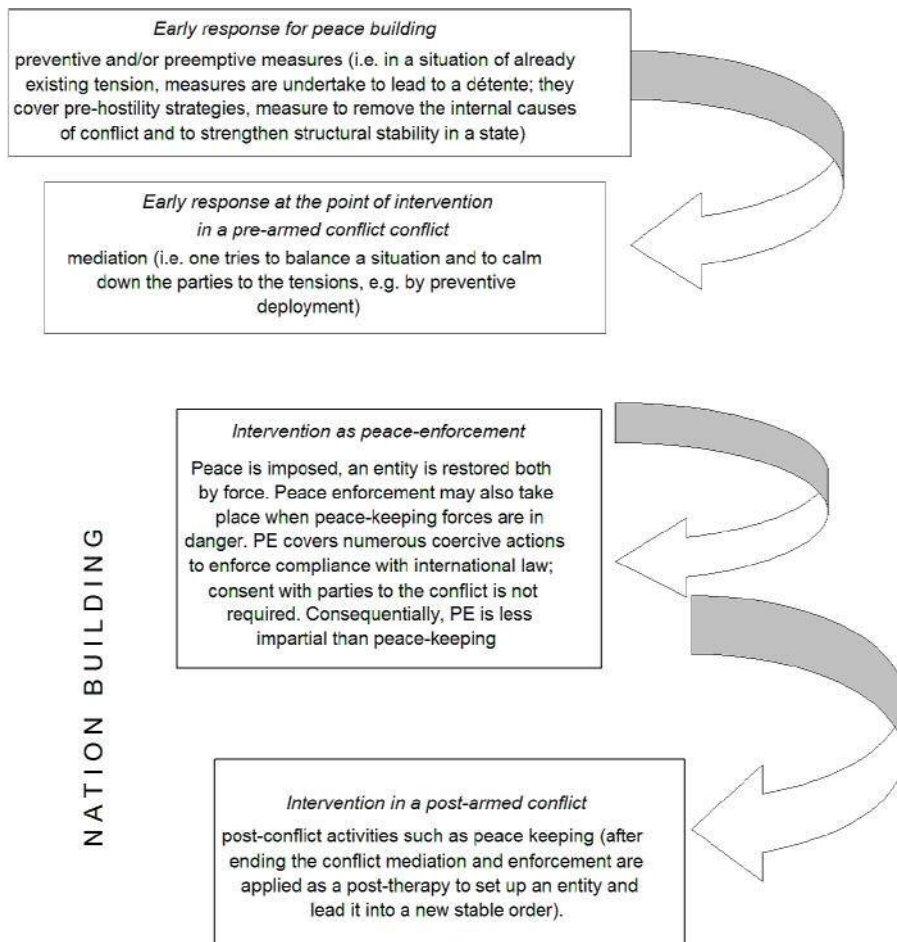


Figure 1. Schematic overview of National Development (Schmidt, 2013).

Sustainable Development

Sustainable development emphasizes the creation of sustainable improvements in the quality of all people through increase in real income per capita improvements in education, health and general quality of life as well as quality of natural environmental resources. Put differently, the word refers to balancing the fulfillment of human needs with the protection of the natural environment so that these needs can be met not only in the present but in the indefinite future. The linkage between environment and development was first introduced in 1980, when the international union for the conservation of nature published the world conservation strategy and used the term sustainable development (Duit, 2007). Sustainable development is also conceived to be structural transformation of the sociopolitical, economic and environmental fabrics of the society that could persist for a long period and guarantee a high standard of living without compromising fate of the future generation. It is achievable in the present trend by only a society whose development policies remain proactive and adaptive to present technology development and modern method of educational delivery.

A sustainable society is one that meets its needs without compromising the ability of future generations to meet theirs (Horsfall, 2013). Actions are considered sustainable if: there is a balance between resources used and resources generated; resources are as clean at end use as at beginning; the viability, integrity and diversity of natural systems and functions are restored and maintained; they lead to enhanced local and regional self-reliance; they help create and maintain community and a culture of peace; and each generation preserves the legacies for future generations. The three pillars upon which sustainable development stands are economic development, social development and environmental protection and it is only qualitative management of education that will provide the catalytic strength need to move the pillars towards achieving a rapid, efficient, equitable and sustainable development in a country (Obi & Obiadazie, 2014). Achieving sustainable development depends on the initiative, resourcefulness, creativity and discipline of human beings who are managers of developmental programmes. However, Pember and Hember (2019), referred to sustainable development as, the ability to meet the needs of the present while contributing to the future generation needs. Hence sustainability is a process which tells of development of all aspects of human life affecting substance. Science education for sustainable development consequently promotes competencies such as critical thinking, imaging future scenario and making decision in a collaborative way.

The overall goal of sustainable development is the long-term stability of the economy and environment; this is only achievable through the integration and acknowledgement of economic, environmental, and social concerns throughout the decision-making process (Nwachukwu, 2012). Science education for sustainable development allows individuals to acquire the knowledge, skills, attitudes, and values necessary to shape a sustainable future. In this case, Science education for sustainable development incorporates key issues such as climate change, poverty reduction, disaster risk reduction, and biodiversity into teaching and learning. Brundtland Commission (2011) defined sustainable development as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. In other words, it means a better quality of life for everyone, now and for generations to come. United Nations Millennium Declaration identifies environmental protection, social and economic developments as the inseparable components of human progress.

Science education is a sure tool for national development and transforms the world both intellectually and physically. According to Aina (2013), Science education has been recognized as the main drivers behind increasing productivity and a key long – term lever for economic growth and prosperity. Science Education is a fundamental tool for implementing the 2030 Sustainable Development Goals (SDGs) as it supports both economic growth and environmental sustainability, developing new and more sustainable ways to satisfy human needs and empowering people to drive their own future (Enrico & Lingerberg, 2015). According to the 2030 Agenda as indicated by European Union, Science education will provide the following opportunities: serves as powerful drives of economic growth, enabling regulatory and governance frameworks, promotion of co-operation and partnerships between stakeholders etc. However, in Nigeria the dividend of science education is yet to be pronounced despite all efforts being made by various governments and agencies. Consequently, the overwhelming call for preparation of a citizenry capable of competing in an increasing global society that is highly influenced by science and technology brings to bare the need for qualitative science education and not the theoretical approach to learning or the memorization of facts. According to Maclean (2018), the new world order and the globalization agenda of the present century are controlled by development of science.

Sustainable development includes social well-being, which depends on education. Information technology has emerged to spread shared knowledge and is a primary driving force behind education reforms. The introduction of new technology-assisted learning tools such as mobile devices, smartboards, MOOCs, tablets, laptops, simulations, dynamic visualisations, and virtual laboratories has altered education in schools and institutions. The Internet of Things (IoT) is proven to be one of the most cost-effective methods of educating young brains. It is also a robust mechanism for integrating a world-class learning experience for everybody (Oyagiri & Ekoh, 2013). Educational technology businesses are continually attempting to create novel solutions to expand access to education for individuals who cannot obtain adequate educational facilities. Social media as a learning tool has come a long way. Large numbers of teachers and students use social media as an essential element of the overall e-learning experience. It is a critical venue for exchanging information about crucial topics these days. Aside from the ability to communicate information anywhere, at any time, social media sites are also a fantastic source of producing networking possibilities to establish social activities and possibly new jobs (Dudar, Riznyk, Kotsur, Pechenizka & Kovtun, 2021).

Traditional classroom instructions fall short of providing an immediate learning environment, faster evaluations, and more engagement. In contrast, digital learning tools and technology fill this void. Some of the efficiencies such technologies provide are simply unrivalled by traditional learning methodologies. With smartphones and other wireless technology devices becoming popular among the general public, it only makes sense that schools and educational institutions make efficient use of them by putting technology in the classroom. Indeed, today's technology's adaptability and non-intrusive character make learning more appealing to the next generation. However, it may be a formidable technique to manage initially since traditional instructors are hesitant to include contemporary technology and gadgets in school, viewing them as a distraction rather than an intelligent learning aid (Schelly, Anzalone, Wijnen & Pearce, 2015). Student might become more engaged in learning if technology is incorporated into the classroom. Because youngsters nowadays are accustomed to the usage of electronic gadgets, incorporating them into schooling would undoubtedly assist in

piquing their interest and enhancing their involvement levels. Integrating technology into education provides students with an engaging learning experience, allowing them to remain more interested in the subject without being distracted. The use of projectors, computers, and other advanced technical tools can make studying engaging and entertaining for students. Student learning can become more dynamic and engaging by establishing tasks in class that incorporate technology resources, oral presentations, and group participation. Participation can extend beyond verbal communication as well (Jevsikova, stupuriene, Stumbriene, Juskeviciene & Dagiene, 2021).

Using computers and other devices with digital tools allows students to take a more proactive role in the learning process (Carmichael & Jordan, 2012). The instructor becomes a guide in this process and can approve learning efficiency. Using the myriad of digital resources, learners may download the required information or upload their content. The web 2.0 technologies (wikis, podcasts, blogs etc.) facilitate learners to generate content, collaborate with others, assess each other work and move toward co-learning. Digital technologies make it easy to use classroom tactics like gamification or approaches like flipped classrooms that optimise learning. Learning landscapes have evolved as a didactic tool that mixes several techniques and enables distinct itineraries to be presented to each student. Technology makes the instruction more inspiring and meaningful (Abdullayev, 2020).

Digital Pedagogy

Today, digital pedagogy has become a vital part of education, irrespective of higher and lower education. The transformation in education generally and science education in particular via the development of ICT is overwhelming in the continuation of revolutionary support of the internet and utilization of network-linked devices. Accordingly, unique instructional and educational modalities have emerged, raising new situations and scenarios to shape different stages of training. Contemporary modalities for virtual training include the Massive Open Online Courses (MOOCs) platform, which utilizes ICT on e-materials, e-books, videos and e-transcript facilitating learning (Marks & Thomas, 2021). These methods have been advantageous in their adaptability and remote utilization at any time and to increase the prospects of ubiquitous learning without any restriction on place and time. "A limitation of these methodologies is the lack of interaction in courses, which may affect learner motivation. Further, e-learning, ICT-based modalities are mechanisms to improve access to education. Using such technological tools, the learner develops innovative solutions to the most prominent issues and problems that arise in the society (Evans & Nation, 2013).

According to "United Nations Educational, Scientific and Cultural Organization (UNESCO)," "Education for sustainable development aims to give people the skills and knowledge to find solutions to economic, social, and environmental problems. It encourages students to reflect on excess consumption, poverty, the stimulation of solidarity and cooperation, and to recognize that current economic development trends are not sustainable" (UNESCO, 2017). In turn, it has created an obligation for each institution to inculcate these requirements among its programs. Pedagogy is a teaching method, and it is adopted by a teacher, which involves teaching styles, theory, assessment and feedback. Pedagogy depends on various factors such as the social system, the content of information, and the receiver. An individual expresses the pedagogy of teaching by referring to the educator, style of delivery on the content to the class.

Digital classroom

Digital classrooms are defined by using electronic devices or platforms such as social media, multimedia, and mobile phones to teach students. With digital technology in education, today's educational landscape has altered for the better or improvements. Digital learning is a learning strategy that employs technology to fulfil the entire curriculum and allows students to learn quickly and rapidly (Nkomo, Daniel & Butson, 2021). The digital classroom entirely focus on teaching via the use of technology. Students use technological or internet-connected gadgets like laptops, tablets, Chromebooks, etc. Instead of taking notes on what the teacher has taught, most of the curriculum is delivered to students online through an engaging and interactive platform. Despite its many facets, education is fundamentally a kind of communication. The internet has resulted in the rise of new communication channels, which have extended the options for the transmission and access to educational information. These media and virtual venues serve as learning facilitators (Beldarrain, 2016). Teachers can use feedback loops to provide feedback depending on many factors such as student, lesson, group, etc. PPTs, video presentations, e-learning methods, online training, and other digital approaches are increasingly used in the teaching-learning process (Camilleri & Camilleri, 2021). As a result, classroom instruction is becoming more participatory. Students may now learn many topics on their own by using internet resources and digital classrooms. In schools, colour charts, graphs, and models describe the finest instruction of the class. However, they are now considered old-fashioned methods of giving education. Education in the classroom is no longer restricted to reading books, writing on the blackboard to explain chapters and concepts, and taking notes in their books (Kryokov & Gorin, 2017).

Importance and Benefits of Digital Pedagogy

Digital pedagogy values open education renovated from a space where users passively retrieve data and information, conveyed by specialists to a participatory, verbal, or non-verbal platform's extended communication ability. At present, technology 'web 2.0' includes 'Social Networking Applications,' 'Blogs,' 'Wikis,' 'Web-based Presentation Tools,' and 'Online Mind Mapping Tools. In particular, to higher education, the institutions promoting unique and innovative approaches, methodology, tools, and techniques to integrate ICT and pedagogy at various educational levels. The use of technology is an inseparable part of digital pedagogy, and it is advantageous only within the framework of fitting pedagogy. However, any "Technology cannot serve as a substitute for the Teacher." In the 21st Century, ICT has led to sweeping changes in T & L process and offers ample opportunities for the learning community (Arkorful & Abaidoo, 2015)). At present, digital pedagogy has been increasingly augmenting the teacher-student relationship. It is found to be teacher-friendly and student-centric to reap many benefits from the participation of the learner community. Firstly, Learning Culture has prominently increased with the usage of Web platforms and tools of ICT. ICT tools are more convenient and affordable and generic. 'New ICT skills' with 'New Literacy' are not limited to reading paper, books, and texts. Proficiency in Word Processing skills creates a close link between literacy and Language development.

Database and spreadsheets, Blogs, Wikis ("What I Know Is"), emails, web design and creation, skills on web search, programs on drawing and graphs, digital videos, even other gadgets like webcams, walkietalkies, software on audio and video recordings encourage development on T & L for speaking and listening skills. By

building autonomy, self-confidence, self-determination, freedom, a healthy culture of teaching & learning motivates learner communities to find their inner creativity, self-sufficiency, enthusiasm and become trendsetters in particular to higher education. Secondly, innovation and creativity grew to concentrate and imbibe among students' community to instill creativity and build their interest in exploring new ideas, knowledge, and skills. Mobile learning can be made possible through creative teaching-learning strategies and academic support strategies to develop support and enhance learner-driven innovation. Personalized learning experiences spread benefits to distinct learners, thus increasing the chances of the aspirant learner to have good skills and knowledge. Thirdly, student engagement, empowering students with accessible resources with the support of digital platforms could be beneficial to interact, contribute, reconfigure, share, and redeploy information and resources. Fourthly, with Open Educational Resources (OER) collaborated, T & L collectively share information, resources and knowledge (Beldarrain, 2016). Digital pedagogy ensures access to geographically dispersed experts, involves a multidisciplinary approach and exchange of knowledge. Importantly, T & L has more flexible at any time and from any place without limiting the educators' creativity. However, digital pedagogy contributes to high-quality educational process, reaching and connecting remote students for any data, information, or resources and transformed capabilities of both teacher and learner without harming the educational system.

Influences of Digital Pedagogy

Digital pedagogy has become a study to employ up-to-date digital technologies in teaching and learning, perhaps applied to the learning environment either online or face-to-face. It allows reading, accessing, retrieving, and reacting to course materials on digital platforms and devices such as mobile phones, tablets, PCs and laptops. It is not only using digital technologies in teaching rather, using ICT platforms from a critical pedagogical perspective and utilize electronic devices to augment the experience of education. Digital technology is influenced through the following concepts like MOOCs (Massive Open Online Courses), online discussion forums, LMSs (Learning Management Systems), Gamebased learning and its environments, Computer programming, Coding, and Virtual and Augmented realities, "BYOD" (Bring Your Device), "BYOT" (Bring Your Technology), "BYOC" (Bring Your Connectivity), "Maker Spaces," "Blogging," "MicroBlogging," "Wikis," "BackChannels," "Audio Recording and Music Making," "Image and Video Editing," "Creation of InfoGraphics," "Slideshows and Presentations," "Digital Storytelling," "Social Media," "Collaboration Tools and Mobile Apps". Further, Sustainable Learning is an innovative idea to create and increase sustainable courses and methodology of learning and teaching that infuse in the learner the skills and outlook to prosper in the complex and challenging state of affairs and positively contribute to make the world a better place. Creating virtual or physical 3D models, Software for Statistical analysis, Analytics, Gesture based interfaces and Rubric generators are the important learners' access technologies. An online response system includes survey and voting polls, video conferencing, cloud computing.

Challenges of Digital Pedagogy

The Digital era at present in India brought widespread challenges to the educational sector. Digital technologies bring in new opportunities and challenges for teachers. Incorporating identified new opportunities in academia into the curriculum

and instructional strategies and practices poses a significant challenge for teachers and policymakers. Firstly, the barriers are integrating ICT in teaching & learning with limited time, resources, and technical support. Secondly, the barriers are teachers' beliefs in ICT and their utilities, skill enhancement and practices in the classroom. While the traditional teaching approach has been gradually losing and decreasing its lure, the learners in the current era need different skills like effective communication skills, critical thinking and innovative skills, thinking creatively, problem-solving ability, negotiation and collaboration skills to accomplish expected results. The most common challenges for the teaching fraternity are updating and developing skills systematically to suit the radical change in digital pedagogy (Nkomo, Daniel & Butson, 2021).

The ICT usage has been tremendously increasing and becoming the need of an hour. Integration of ICT in T & L is viewed as a revolutionary educational change in terms of high-tech education, in particular to higher education. Through the application of electronic bases such as multimedia, productivity software, and cloud computing, digital pedagogy focuses on ICT technologies, tools and skills, modes of operation in the digital world. Digital pedagogy in T & L is found to be difficult. However, it is significant and essential for an educator to play a vital role as a promoter, motivator, and transmitter on a quest for knowledge. There are several difficulties that teachers face in incorporating ICT into the T & L process (Camilleri & Camilleri, 2021). Constantly, the teaching fraternity must develop and maintain their pedagogy to keep abreast with the latest technologies. It is important to track the productivity of teacher-student interaction and ensure the sense of autonomy among the learners. In this line, the efficiency and effectiveness of learners increase to handle real-life challenges on their own. Consequently, it is crucial for every teacher to recognize the learner's strengths, wants and needs to make interactions meaningful and teachers have to create the appropriate teaching ambiance, style.

Nowadays, the current generation of students is active learners', appetite for technology and enthusiastic. It is a big challenge for the entire teaching fraternity to create a sustainable future. Therefore, teachers are required to be more innovative and creative in designing their instructional strategies. Creating awareness, learning engagement & active participation must be well addressed by the teachers in the usage of Digital Pedagogy.

Conclusion

Digital pedagogy is more innovative, and it makes learners acquire skills from all directions beyond the course content. Learners can focus more and continuously learn from digital pedagogy, which has no time and physical frame. It inspires pupils to learn more effectively, which results in sustainable learning. In the 21st Century, the culture of teaching and learning is mandated to grow in education. Digital technology in the classroom refers to various software and gadgets meant to help students with accessibility needs. The most effective way to reduce the number of repetitive, time-consuming duties a teacher undertake is to use technology in the classroom. Educational technology applications may save a lot of time and energy by automating or partially automating day-to-day operations like attendance tracking and performance monitoring. Students are taught how to use technology responsibly and strategically, which can help them make decisions and develop self-discipline. Technology in science education can help students to prepare for lifelong learning. These technologies provide students with a virtual world and the freedom to access digital knowledge according to

their learning styles. Thanks to digital content production tools that customise teaching and learning, students can study at their own pace. The digital classroom uses electronic devices and software to instruct students and incorporates technology into education. A traditional classroom is transformed into a digital classroom through computers and the Internet. Students can learn more efficiently and track their progress with the help of technology and sophisticated equipment. The current era is expected to develop educators, learners, infrastructure and a supportive environment. There are several incidents that have reduced student interest and morale due to lack of technological advancement at classrooms and laboratories. However, the development of digital pedagogy with the influence of ICT platforms can take a huge step towards transforming both science educators and learners. Therefore, creative pedagogy, virtual learning in any place and any time concept are speeding up learning and teaching. Several factors and challenges exist in creating effective digital pedagogy for sustainable development. Thus, as long as teacher adaptability on digital pedagogy is good, it can serve learners and create bonding without technology. Hence, “Technology cannot serve as a substitute for the Teacher,” and it retains both the educator and learner relationship as a whole.

Recommendations

Based on the foregoing, the following recommendations have been put forward

1. Ministries of Education and Boards should embark on the training and retraining of teachers by sponsoring study leaves, workshops, conferences and seminars on technologies for teaching and learning.
2. Science teachers should be encouraged to embrace the 21st century pedagogy and integrate modern digital technologies into their instructional strategies. Their salaries and other welfare packages should be revisited positively.
3. There is an urgent need to restructure the existing curriculum at all levels of education to reflect 21st century science process skills and global best practices.

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