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Research Article

The Trajectories of Science Education in Nigeria and its Challenge to Sustainable Development

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Abstract: The paper reviewed science education in Nigeria from the pre-independent era to date and its challenge to sustainable development. The various efforts of the government and other stakeholders at developing science education were highlighted in the paper. It was argued that science education is crucial to the sustainable development of a nation. However, achieving sustainable development in Nigeria has been difficult due to the challenge of the quality teacher. Most teachers have poor knowledge of integrating technologies in teaching and also do not have an adequate understanding of authentic learning in science. The review considered the teacher as a link between science education and sustainable development. The article was of the view that the solution to the challenge is teacher possessing adequate technological pedagogical content knowledge (TPACK). Others include teacher enhancing the scientific literacy of students and critical thinking skills.
Keywords: Authentic learning, critical thinking, science education, scientific literacy sustainable development, TPACK.

INTRODUCTION

Science education is crucial to the development of any nation in the world [1, 2] Science education has been defined in so many ways by different authors but, this paper is looking at science education in two perspectives: first, as the teaching and learning of science and secondly as a field of study. Many of the developed countries had prioritised the teaching and learning of science in their schools while some are not [3]. The Nigeria case is similar to the latter. However, the teaching and learning of science in Nigeria has been ineffective [4] due to many factors. According to [5], science teaching and learning in Africa has been grossly inadequate. Science education in Nigeria is taught in senior secondary school as Biology, Chemistry, and Physics [6] while it is considered as a field of study in higher education. Many Nigerian universities have degree programme in science education up to doctoral level. Students' enrolment and attitude to science education are worrisome [7, 8]. Science teaching and learning in Nigeria was dated back to the time of informal education; it was in the form of storytelling and by imitation at this period [9]. Science education is essential to nations and individuals. It promotes a culture of scientific thinking and helps to understand our world [10]. It is also essential for the economic well-being of the citizens [11].

The post-independence era witnesses an increase in pupil enrollment resulting in more schools being established immediately after independence. The coming on board of both the West African Examination Council (WAEC) and the Science Teacher Association of Nigeria (STAN) in 1952 and 1957 respectively was significant to science education in Nigeria. The collaboration of STAN, the Ministry of Education and Comparative Education Study and Adaptation Centre (CESAC) brought Biology, Chemistry, and Physics into Nigerian schools in 1968 [9]. The development of science education in Nigeria includes the creation of the Nigerian Secondary School Science Project (NSSSP) between 1970 and 1972 by the CESAC. The birth of NSSSP yielded encouraging results that caused changes in the organisation of science content at the secondary school level. The evolvement of NSSSP is believed to be the foundation of science education in Nigerian schools today.

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Science education is critical to sustainable development in any country in the world [12]. The development that meets the citizens' present needs while the future needs are not compromised is called Sustainable development [13]. Sustainable development is a critical concern of the present day's policies across the world [14]. The three components of sustainable development that works together given by the UN General Assembly in 2005 are economic development, social development, and environmental protection [13]. To achieve the three components in Nigeria has been a herculean task due to challenges created by poor science education. A nation that does not provide sound science education for the youths through quality teacher education programme has already compromised the needs of the posterity of that nation.

The Quality Teacher in Science Education

The teacher is vital to the sustainable development of any nation including Nigeria. The teacher remains the most valuable resource in the educational sector of any nation [15]. According to [16, 17], impacting students' achievement depend on the teacher. Teachers have a critical role to play to adequately prepare students for achieving national objectives in society through quality teaching and character modelling [18]. The quality of any educational system is dependent upon the quality of teachers regarding academic and professional qualifications, and the level of dedication to their teaching functions [19]. Teachers at all levels of the educational system are essential in the overall development of any nation [20]. Teachers are regarded as one of the most important variables that drive the effectiveness of schools and the quality of a child's education [21]. For instance, the study of Physics as a course depends much on the teachers' teaching quality [22]. According to [23], the attainment of excellence in high school Physics will collapse where there is no well-educated, strongly motivated, skilled and well-supported teacher. Teachers at all levels of the educational system are paramount for the sustainable development of a nation [24].

Given this, the federal government of Nigeria establishes institutions to train teachers for the need of the nation. Thus, the National Policy on Education stipulates the programme for Nigerian teacher education. The purpose of this education is to produce well qualified professional teachers that can adjust to the changing needs of the students [25]. Teacher education programmes are not only to impart the teacher trainees with knowledge but, to inculcate in them the repertoires and competencies to function effectively in a changing educational world. To achieve these set goals require the establishment of different institutions for the teacher training in the country. These are Colleges of Education, Faculty and Institute of Education in the universities, Schools of Education in Polytechnics, National Teachers Institute, Nation Institutes of Nigerian Languages and National Mathematical Centre [26].

The various teacher training institutions as mentioned above have been responsible for the training of all categories of teachers in the country including science teachers. However, research studies indicate that it has been confronted with different challenges which affect sustainable development. According to [27], the persistent anti-intellectualism of those in power has been a significant challenge in teacher education. Most of the Nigerian leaders have in many ways behaved as teachers' enemy through poor welfare for teachers [28]. This is apparent as the teacher training institutions are deficient of modern learning resources. The majority of the student teachers have no good teacher education [29] because the resources to train them are not provided. Funds and modern day technologies are absent in teacher training institutions [26]. The teachers need to imbibe the modern technologies and methodologies of the advanced countries of the world [30] in their day to day activities in the classroom. The teacher quality is so crucial to academic achievement, and where it lacks, it is detrimental to the achievement of practical education [31].

Science teaching in most of the Nigerian institutions is by mere storytelling. The sad thing is the recycling of these poorly prepared teachers in Nigerian schools. Therefore, the current crisis in Nigerian education and society could be ascribed to the neglect of teacher education and the gory plight of the teachers [18].

It is not an understatement that the teacher is the hub around which the education of any nation revolves. Consequently, quality education is critical to sustainable development and progress of modern nation-states [32]. For national sustainable development, the teacher should be able to produce graduates who can put what was learned into practice. Science is in every sector of the economy today. Therefore, to develop Nigeria and preserve the development for a generation yet unborn requires science education that can transfer scientific knowledge to usable technology. However, this has not been the Nigeria situation. Most of the graduates produced in Nigerian schools are more of those who know the theory of science but cannot do science. They can explain (verbalise) science and identify (visualise) science concepts but cannot apply (do) science. [12] conceptualised these graduates as 'Verbalisers', 'Visualisers', and the 'doers'.

The preceding narrative is seen as a severe challenge to sustainable development in Nigeria. Figure-1 below is used to conceptualise the challenge of science education to sustainable development in Nigeria as narrated above.

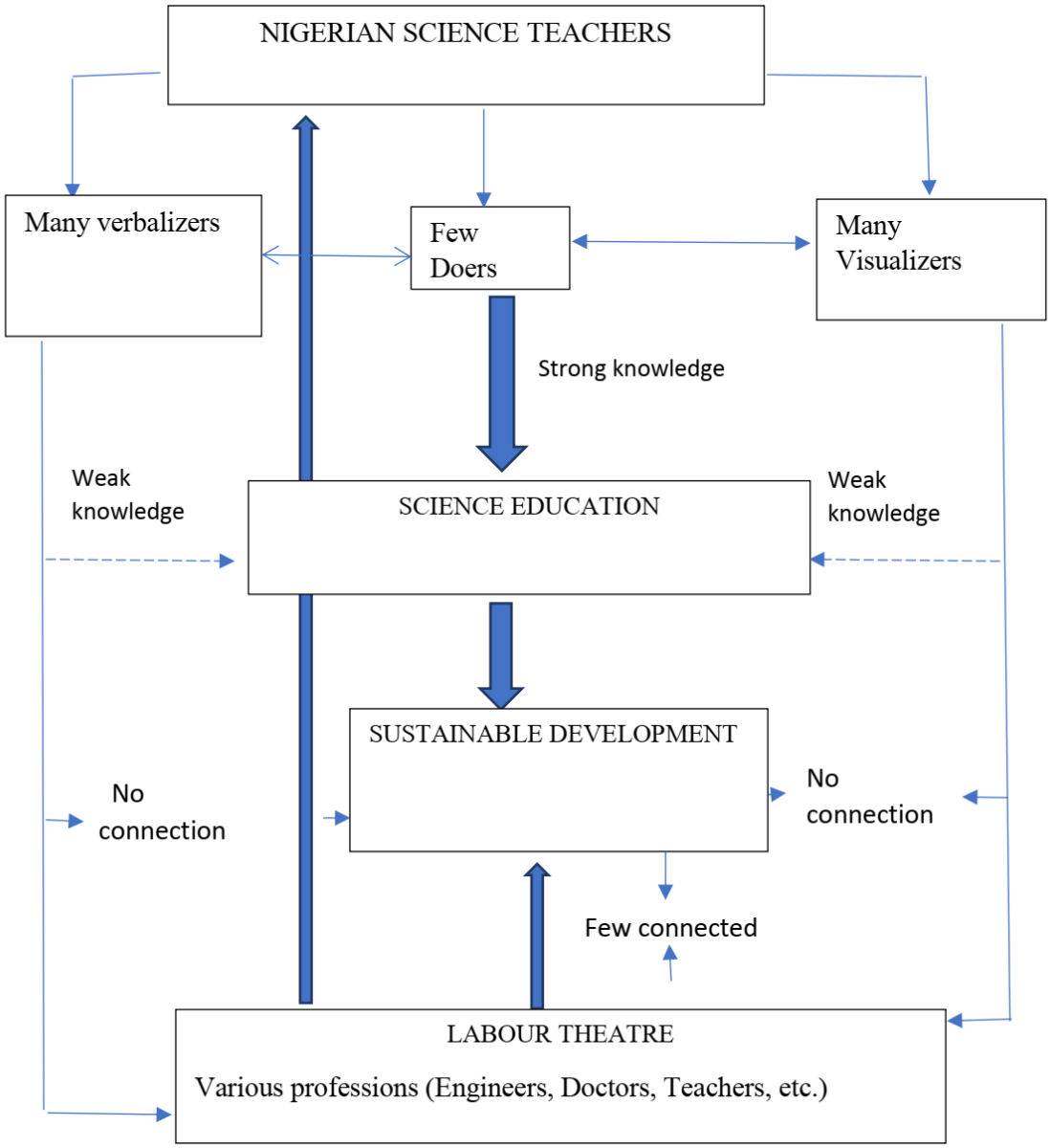

Fig-1: The connection between science education and sustainable development in Nigeria
Source: [33]

The Link between science Education and Sustainable Development

The link between science education and sustainable development is the teacher. However, the situation in Nigeria education system indicates the break in this link which forms the major challenge to sustainable development. Figure 1 above illustrates clearly the link. Science is taught in schools with the aim of producing human resources for the country needs without depending on the expatriates from foreign countries as done in many years back. It is unfortunate that the majority of the students produced in schools are filled with the head knowledge of science without the required repertoire to function outside the school. Only a few of these graduates are capable of using scientific skills to function independently after schooling. These graduates are categorised into Verbalisers, Visualisers, and the Doers [18]. The verbalisers can correctly explain any scientific concept but cannot transfer the knowledge of the concept to any usable technology. Similarly, the visualisers can give a graphical illustration of any scientific concept and identify such concept among many others but, cannot apply it meaningfully. The Doers may be able to explain correctly or not but, can transfer the skills acquired to usable technologies.

It is worrisome; the Nigeria science teacher produces many verbalisers and visualises but few doers [33]. The knowledge both the verbalisers and the visualisers have about science education is weak because it is devoid of life-sustaining skills. According to [34], students are supposed to possess practical skills in their area of specialisations to function independently

in the changing society. The industries are changing and revolution everywhere in the world which requires that students be active learners and possess required skills. Youths need lifelong skills that must be concrete, easy to learn, and transferable [35]. The Nigerian experience shows that most students did not do science but memorised it [36].

For instance, graduates of Biology, Chemistry or Physics with good certificates are roaming the street of the city capitals seeking for jobs. These graduates know Fishery, Dye or Solid State Materials which they can turn into a viable job [37]. Nonetheless, they could not, because many of them are verbalisers and visualisers. The pencil and paper knowledge of science education possessed is weak for practical application; thus, disconnected from sustainable development. Youths would be able to overcome many of their problems if teachers impart life skill education [38] on them through science education. Science teachers are unable to impart life skill education because of some problems peculiar to the teaching profession in Nigeria as discussed below.

Science Education Teacher's Challenges in Nigeria

Science education is faced with a challenge of quality teachers globally; it is not Nigeria problem alone. However, the challenges of technological pedagogical content knowledge (TPACK) and authentic learning are exclusively considered for the Nigeria teachers in this paper

Teacher's effectiveness to integrate technology in teaching is a vital issue in most educational institutions of the world in recent time [39]. It implies the use of technologies for teaching science in school is no longer an optional but, should be part of what a science teacher need for effectiveness. The Nigeria experience shows only a few numbers of Nigerian science teachers are technology savvy. Most Nigerian teachers have inadequate knowledge, and use of ICT [26], thus the need to train and re-train the teacher in ICT is germane [25]. Information and Communication Technology (ICT) is a veritable tool to achieve sustainable development by any nation to empower citizens for global competitiveness [40]. The provision of computers in schools is not a guarantee that teachers would integrate technology into teaching [41]. However, being able to use the devices by the teacher for teaching is vital to the nation.

The position of ICT is critical to the teaching profession in any clime because, the complex relationship between the technology, content and pedagogical knowledge cannot be understood without it. For the teacher to understand the complex relationship between content, pedagogy, and technology are to train them on how to use technology [42]. Good teaching with technology involves three core components which are content, pedagogy, and technology [43]. At the heart of good teaching with technology are three core components: content, pedagogy, and technology, plus the relationships among and between them. These three core components are the principal domains of TPACK. According to [44], the three core domains of TPACK are technology, pedagogy, and content. TPACK is a critical part of teachers' knowledge required to practically apply to his/her everyday practice [45]. From practical teaching viewpoint teachers' TPACK is central to teaching effectiveness and is an ultimate goal for all teachers.

TPACK could be a theoretical framework which helps teachers to examine how to incorporate technology into teaching [44]. Effective integration of technology into teaching requires teachers not only to know about technology, pedagogy, and content but also to master the interplay between the three domains of core knowledge [44].

TPACK should not be an innovation in Nigeria education system because, according to [41], it has been a framework in the USA and the world at large to guide teacher learning's research on the integration of technology in the classroom. TPACK emphasises the importance of helping teachers develop and apply integrated and interdependent understandings of technology, pedagogy, content, and context [46].

TPACK is a form of professional knowledge that technologically and pedagogically well skilled, curriculum-oriented teachers use when they teach [46]. TPACK is a specialised, highly applied type of knowledge that supports content-based technology integration [47]. Teachers are deficient in the use of technology in teaching [48] more specifically the Nigeria teachers. The development of TPACK by teachers is critical to active teaching with technology [43].

TPACK is so essential to the teaching profession today that the lack of it brings a lack of authentic learning in science. Authentic learning is crucial to science education because it helps the student to do science rather than memorising it. According to [49], authentic learning has nine elements which are critical to active science learning. These elements are authentic contexts, authentic activities, expert performances, multiple roles and perspectives, collaborative construction of knowledge, reflection, articulation, coaching and scaffolding, and authentic assessment. Each of the elements is vital to science education as regards to the mastery of scientific skills.

Authentic learning makes science real, and the learning task has a real-life resemblance. It makes the science knowledge relevant and retrievable in real-life [50]. It is profoundly disturbing because most of what the science teachers taught students are not relevant and not retrievable in real-life experience. The world is in a

digital age and education is depending much on the modern technologies for students to be able to retain the learned concepts for a more extended period. The argument of neuroscience about rote and spatial memories is essential here [51, 52]. Students remember information stored in spatial easily without any rehearsal because they were actively interacting with the environment (technologies) during learning.

Conversely, the rote memory supports memorisation of information because; students are passive learners depending only on the information from the teacher. Research shows that most of what is learned by Nigerian science students is by memorisation [36]. It thus implies that they make use of the rote memory because; students were passive learners and without authentic learning experience.

Authentic learning makes student active-learners through interaction, collaboration, articulation, and reflection by exploring potentials in technologies. It is therefore essential that teachers possess the required repertoire to make the science students active learners through authentic learning. According to [53], the expectation is high on the role that technology can play to achieve active learning. It is through the students' active learning that science education would be able to support national sustainable development.

To meet the national needs of the three components of sustainable development, economic development, social development, and environmental protection require active students learning. Most graduates who should have been job providers are now job seekers in Nigeria as a result of the poor quality of science education. They have the knowledge which cannot be used to create jobs, have certificates but no skill and increasing youths unemployment every year. This contributes primarily to the Nigeria poor economy. Due to the growing rate of youth unemployment, there is insecurity everywhere in the nation. The youths who have knowledge but no skill became kidnappers, arm robbers, political thugs, and others. Most of the insurgents are graduates with certificates but no skill to make them independent of the government jobs. Provided many of them have the skills required to work independently, it is possible they would not take to crime.

Another obvious challenge of science education teacher in figure 1 above is out-of-field teaching. It is when a teacher is teaching a subject he or she has no qualification to teach or teach at a level not trained for. According to [54], out-of-field teaching is when teachers are teaching out of their field of qualification. Figure 1 shows that most Nigerian graduates lacked the required skills for job creation and end up in the 'labour theatre'. In this theatre, there are engineers, teachers, medical doctors, geologists, accountant, and others. These cohorts of graduate depend on the paid job because they lacked skills to do anything independently. It is sad that many of these are recycle back to schools to teach because teaching profession in Nigeria is cheap to get either qualified or not. It is common to see engineer teaching Physics and Mathematics in Nigerian schools [55]. The resultant effect is that most of these out-of-field teachers lacked the required pedagogical content knowledge (PCK) to teach science. PCK is a core domain of TPACK and critical to the teaching profession.

More worrisome is that a few of those in the 'labour theatre' who got the skills to do something was not supported by the government. Most of these people were being hired by the politicians as thugs while some used their skills to commit crimes. Many of these are the fraudsters who specialises in Cybercrime and many high degrees of crime in Nigeria today. The insurgents in Nigeria are technologically advanced: they manufactured explosive and other dangerous weapons. These are young scientists that the nation should have made use of for sustainable development.

Solutions to Achieving Sustainable Development through Science Education

Nigeria as a nation can achieve sustainable development through science education if the nation is more committed to the science teacher education programme. The present teacher education programme may continue to fail science teachers except for something positive is done. There may be other ways but, the present review is looking at the science teacher as a link between science education and sustainable development.

We are in the 21st century, and we should move along with the world. The Nigeria government and all stakeholders in education should stop depending on the certificates but the skills. Given this, TPACK must take a critical position in the training of science teachers in all the teacher training institutions. The seven domains of TPACK must be taken seriously in the training of teachers. The domains are technology knowledge (TK), content knowledge (CK), pedagogical knowledge (PC), pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK). The overlapping of the six domain brings the last seventh which is technological pedagogical content knowledge (TPACK). The adopted TPACK Framework in figure 2 from [44] succinctly explain the interactions of the seven domains.

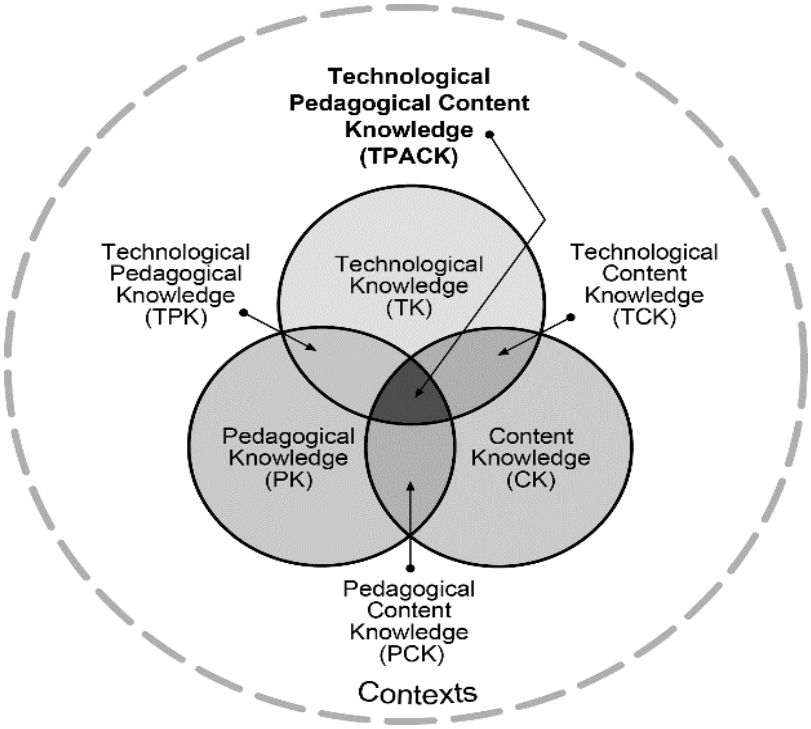

Fig-2: TPACK Framework [44]

The present way of teaching science in schools cannot continue. Many teachers cannot booth a computer not to talk of teaching with it. It is entirely not right to always supply the science students with learning information but, they should seek for the information by themselves. Many science teachers still give a lecture note to students and also expects them to memorise the concepts at this age of digital technologies. Some teacher does not know how and when to integrate technology into teaching at this era of emerging digital technologies [45]. Developing TPACK is crucial to effectively teach with technology by any teacher [43]. A few numbers of universities had focused on the introduction of ICT in education to enhance the teaching and learning of science [41].

It should be noted that scientific literacy is essential to science education. According to [56], scientific literacy is one of the critical objectives of science education. However, research suggests that most science teachers are not scientifically literate [57]. Scientific literacy may not have a specific meaning for being a polysemous construct. Nevertheless, scholars have a convergence perspective this review explores. Scientific literacy is the knowledge and understanding an individual has of scientific concepts and processes needed for making a personal decision, take part in civic, cultural affairs and economic productivity [58]. For [56], scientific literacy is being able to make practical life decision using scientific knowledge.

Sustainable development requires that both the teachers and students are scientifically literates. It implies using the acquired scientific knowledge and understanding to make decisions that impact lives and society positively. It is unfortunate that many of our students depend on the teacher and textbooks for learning. Students in most developed countries do not take the teacher opinions as final in science learning but, verify facts through different means. One of these means is through scientific argumentation. Scientific argumentation according to [59], is attempting to validate or refute claims in ways that reflect the values of the scientific community. Argumentation is a core epistemic practice of science [60]. Thus, the objective of science education should not only be to master scientific concepts but also learning how to engage in scientific discourse. Therefore, students must be able to engage in scientific discourse. The teachers should be well knowledgeable about scientific argumentation. Teachers should allow students to craft scientific arguments and take part in discussions which will allow them to support and challenge claims based on evidence [61]. Scientific argumentation enables students to articulate their understanding of science.

Articulation is an essential element of authentic learning [49] that every student must possess. Most science education graduates cannot defend their scientific beliefs, and such are easily deceived and give in to misconceptions. Most companies and industries are headed by experts from foreign countries because many young Nigerians graduate hold certificates they could not defend. This is affecting the country because; the government pays heavily for the services of these foreign experts. It is essential that scientific argumentation instruction is included in the teacher education programme.

Critical thinking skill is essential to science teaching and learning. According to [62], critical thinkers scrutinise problems; identify assumptions and biases, look for evidence before the conclusion. [63] argued that students who graduated with a deficiency in critical thinking skills would not be able to think critically once in the workforce. Experience shows that most teachers and students' critical thinking skills level are low. It is unbeknownst to many teachers that this is one major causes of students' poor academic achievement especially in Physics [64]. It is worrisome in Nigeria that the government and stakeholders in education are obfuscating the issue of critical thinking in employing science teachers.

CONCLUSION

Science education starts in Nigerian schools long before independence. Several efforts had been made by the Nigeria government to develop it at all levels because of its importance to sustainable development. The challenges confronting Nigeria science teachers as a link between science education and sustainable development had been a lingering issue unknown to many. The teacher has been considered as critical educational variable all nations of the world depend on for sustainable development. The paper argued that Nigeria teachers TPACK is not adequate and it contributed to the problem of producing school graduates who have no skill to create jobs. Scientific literacy and critical thinking were also seen as problems of many Nigeria science teachers and students. Therefore, it thinks that TPACK, scientific literacy, and critical thinking skills should be made part of the teacher education programme.

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