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Assessing Teachers' Preparedness For Integrating Artificial Intelligence (AI) In Biology Instruction In Senior High Schools

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ABSTRACT
Artificial Intelligence (AI) integration in the educational context is transforming science education across the globe and provides the advanced tools that serve not only the pedagogical approaches but also student learning. This study discussed the level of preparation of teachers of Senior High School Biology in the Volta Region of Ghana to incorporate AI in their pedagogy. The study employed the use of a descriptive survey method with a sample of 109 Biology teachers being purposely sampled within the various schools in different districts in the area. The collection of data was based on the use of the Artificial Intelligence Integration Preparedness Scale of Biology Educators (AIIPSBED), which represents a structured scale that aims at assessing the competencies, attitudes, understanding and preparedness of teachers related to the implementation of AI. Examination of all the results showed that an overall moderate level of preparedness was observed among the teachers. The participants proved to have a confidence level in learning and applying AI tools, had some knowledge of related ethical concerns and a good attitude towards welcoming the phenomenon of technological change. However, challenges like poor infrastructure, lack of practical mechanisms and lack of practical training were also established. Markedly, a Pearson correlation test indicated a highly significant ($p < 0.05$), strong positive relationship between the preparedness of the AI integration held by teachers and their perceptions of the value of instructional AI ($r = 0.995$, $p < 0.05$), which signifies the close relation between the preparedness and value. The results confirm the concepts of the Technology Acceptance Model (TAM), as the readiness of teachers to implement technologies increases with the growth in the number of their perceptions of the AI's usefulness and ease of use. The research suggests that focused capacity-building may take place, digital resources must be improved, and the curriculum should be changed so that AI competencies are appended to teacher training programmes. Such strategies would underlie not only efficient, equitable, and sustainable teaching of science through AI in various academic contexts but also would help coordinate the efforts of society in teaching science through AI.

Keywords: Artificial Intelligence, Biology Instruction, Teacher Preparedness, Educational Technology

INTRODUCTION

The educational practices, in particular, teaching methods used, the process of learning, and the administrative operations are being affected by the progressive evolution of Artificial Intelligence (AI). The academic institutions across the world are adopting AI in order to generate pedagogical, school leadership, and security system innovation [21]. According to [1], AI is a system which is technologically advanced and is capable of exhibiting cognitive abilities of a human being to complete tasks that are intelligence-based. In the same light, [4] describes AI as an imitation of the human thinking process, which enables machines to process information and act in various learning settings accordingly. The AI is becoming an important topic of interest in science education as educational reforms are being sought in Ghana in the Volta Region. Nevertheless, the efficacy of the application of such AI is largely based on how ready or willing the teachers are to address and adopt it on a technological scale. All these factors, according to [21], allow teachers who are engaged in AI at an early stage of its usage to become more effective and relevant than their colleagues. [2] Praises the important role of AI in the STEM disciplines, in which it transforms the role of the educator to that of the learning facilitator, instructional designer and assessor of the students. In areas such as Biology, Physics, and Chemistry studied in secondary school education, intelligent technologies such as adaptive testing systems, virtual labs, and intelligent tutors have the potential to redefine classrooms. Such innovations generate more promising, learner-approached, and personalised settings that support teaching science to students despite geographical separation [2]. In a region such as Volta, which experiences a significant difference in infrastructure

between rural and urban regions, AI may prove to be a life-saving tool toward access and provision of education.

[14] state that it is very important to realise to what degree the teachers are willing to embrace AI, as the attitudes reflect greatly on the outcomes of implementation. When it comes to the push towards digitisation in education, the assessment of the levels of awareness, acceptance, and competence of teachers becomes a necessity. [9] emphasise the necessity to determine the way educators understand and use AI tools, as this information can be used to develop specific implementation plans. According to [19], to become effective in improving the educational process with the help of AI, teachers should learn the pedagogy of this technology, the impact on the content of learning, interaction with students, and end with a testing parameter. Akin to this, according to [5], in order to teach technologically advanced classrooms, teachers need to have not only theoretical but also practical knowledge of AI. [3] stresses the need not only to help teachers learn how to effectively use AI tools but also to consider whether they are appropriate, what kind of effects they have, and whether they are ethical to discuss in the classroom environment. The same opinion is voiced by [6] and [7], who support continuous teacher development initiatives that should pay particular attention to incorporating AI in classroom teaching. [8] advise using a proactive approach to minimise the issues that educators may encounter during the implementation of AI, which would ultimately stimulate a more extensive and successful use. The concerns of data protection, ethical issues, and the privacy of the user are especially important. [13] warn that despite the promising possibilities that AI includes, this technology has its limitations. Error in algorithm results and absence of responsibility frameworks can harm the learning progress of the students or reduce confidence in technology.

According to [22], during crises like the pandemic and materials shortage, some educators are swapping in-person teaching objects with their digital facsimiles, e.g., animated videos and interactive simulations (especially in Biology). The same strategy will also be useful in the Volta Region since it requires innovative practices to tackle deficiencies and promote equal provision of science education. [11] states that to align it with the idea of international standards, it is not enough to have an education that is not resistant to AI tools; teachers should also be able to explain competently how to use such tools in their teaching practice to provide modern and more student-centred teaching. Putting all this into consideration, the research is aimed at assessing how ready Biology teachers in the Volta Region are to incorporate AI in their lesson delivery in the senior high schools in the region. It attempts to determine the degree of knowledge, attitude, and capability of using AI tools in Biology classrooms by teachers. The main research question that will be addressed by this research is: How prepared are the Biology teachers in the Volta region to include AI in their classes? Based on this, a null hypothesis that will be tested states that there is no statistically significant connection between the readiness of Biology teachers to use AI in their teaching and their beliefs about the advantages AI offers to the classroom.

The research aligns with the discussion of sustainable development because it addresses the issue of access to quality science education on the principle of equality, particularly in light of the innovation introducing the use of Artificial Intelligence (AI) technologies in teaching biology. Using a data-driven approach of a survey, the research is carried out within the framework of the Volta Region of Ghana, which has unequal access to the digital infrastructure, to determine the level of preparedness of educators and the gaps in the infrastructure that prevent inclusive and technology-based learning.. The results are valuable and can be used to harness the power of AI, enabling educational institutions to move closer to achieving SDG 4 by ensuring inclusive and equitable quality education for all, improving learning outcomes, increasing the efficiency and effectiveness of the educational system, and promoting lifelong learning opportunities. Also, by enhancing teacher capacity-building in digital competences guaranteed by technology innovation within the under-resourced populations. The use of self-reported data in the study presented a limitation, resulting in a compromise in the responses regarding teacher preparedness and attitudes towards the application of AI in the education system. Also, the study had geographical limitations, being confined to the Volta region, which could be a factor that makes the findings not generalisable to other parts of Ghana or Africa as a whole in the sub-Saharan context.

LITERATURE REVIEW

The use of Artificial Intelligence (AI) in the educational sphere has become a distinctive break in contemporary pedagogy that has completely changed the ways of delivering instructions, receiving them by learners and measuring the productivity in diverse educational disciplines. In the sphere of science education, especially in Biology, AI poses enormous opportunities in terms of personalising the learning process, replicating mechanisms of complex biological processes, enriching hands-on learning through virtual models, and aligning the approach to teaching to the specificities of different learners. However, whether these innovations can work or not also depends greatly on how the educators are to embrace the use of such technologies in their

teaching models. According to [20], AI has become an essential ingredient in the modern educational system, which has spread to administration duties and institutional decision-making, too. Teachers are also challenged to abandon the usual instruction paradigm and become technologically competent brokers who are in a position to utilise digital technologies, such as tutoring applications powered by AI, data-driven assessment systems, and interactive graphs. Such technologies can be useful in teaching Biology, e.g. with the instruction of cellular processes, emulation of ecological systems, or the simulation of hereditary trends that could be difficult to learn about in more traditional contexts. The concept of teacher preparedness in this situation is the extent of their knowledge, their views on AI, technical competence, and receptiveness to implementing digital tools in their work.

Various explanations identify professional preparedness as one of the keys to productive AI implementation in classrooms. Specifically, [2] lists AI as a key factor in STEM educational environments, reinforcing the exploratory learning model, simplifying the process of conducting assessments, and facilitating the customisation of instructions. However, such potential is not always exploited in most contexts, whereby in poorer settings, science teachers lack the technological literacy and awareness. [14] in their research further confirm that the perceptions of educators on AI play an important role in informing whether they are ready or not to employ it in instruction. Once teachers understand that AI is an additional source of experience and does not interfere with their power and control over the students, they are more likely to be open to its usage. This opinion is shared by [6], who state that fruitful teacher interaction with AI requires the availability of training courses, positive institutional conditions, and the clarification of the relationship between AI and pedagogical goals. Lacking sufficient introduction to such aspects, numerous teachers might not be eager to resort to the use of AI tools, which could widen the digital divide and hamper the pace of innovation in teaching Biology.

The necessity to redefine what should be perceived as essential teaching competencies within the context of AI-enriched learning comes out in the literature, as well. Teachers are not simply required to choose appropriate AI tools but also to ensure that these tools complement learning objectives, professionals maintain ethical practices, and struggle against the themes of misinformation and information security. According to [7], there should be specific professional development activities which are directed to more than simple technological familiarisation. Such programs are supposed to offer specific science/education-centred instructional strategies where visualisation and the ability to conceptualise are of utmost relevance. Besides, [8] highlights the importance of learning what challenges educators face, including the lack of modern infrastructure, ICT support, and digital skills, to develop effective policy interventions. The situation has been aggravated in most developing nations, especially in sub-Saharan African countries, by unequal access to digital devices and unstable internet connectivity. Therefore, the implementation of AI in Biology classrooms should be accompanied by infrastructure investment and strategic curriculum alterations, after which all individuals will at least be equal in distribution of opportunities to work with it.

One more component of teacher preparedness is ethical awareness. According to [13], teachers should be prepared to face the ethical and practical consequences of AI in schools and universities, such as the issue of algorithm discrimination, privacy, and fake news. Training should also be provided in the responsible use, where teachers know how assessments driven by AI work, and on which occasions they should intervene in order to maintain integrity and fairness. Finally, the dynamic character of the AI technology means that teachers need to have an attitude of lifelong learning and flexibility. [11] states that the idea of incorporating AI during teaching is not just a case of learning to use online tools; instead, it is a new pedagogical paradigm. In the case of Biology teachers, the revolution will entail a transition on the par of rote learning patterns to an emphasis on analytical skills and scientific interests, and digital literacy and fluency, which will be facilitated by artificial intelligence-based pedagogical approaches.

THEORETICAL FRAMEWORK

This study is based on the Technology Acceptance Model (TAM) developed by Davis in 1989, as cited by [3], as a theoretical framework that is used to examine how people absorb and use technological devices. Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) have been found as the two central constructs, which appear to be the major predictors of the inclination of an individual to adopt technology, according to the TAM framework. Perceived usefulness pertains to an individual's perception that, by using a particular technology, it is possible to achieve higher job performance, whereas perceived ease of use brings in the perception that using the particular technology does not require a lot of effort. Regarding the present study, TAM provides a useful angle through which the study can examine the positioning of the senior high school Biology teachers in the Volta Region to incorporate Artificial Intelligence (AI) in their instruction. As soon as teachers understand that AI technologies will help them to increase teaching efficiency, stimulate more active student involvement, or better understand complicated biological mechanisms, they are also

more willing to view them as indispensable in-class tools. Similarly, teachers will show higher levels of readiness and acceptance when these technologies are viewed as simple, intuitive, and easy to use and those that can be combined with the current methods of pedagogy. It is important to note that due to the current evolution of digital technologies sweeping educational settings, TAM is growing in relevance as a way to both examine the influence of psychological and pragmatic issues motivating educators to adopt certain technologies. The model illuminates not only the intentions of teachers to use AI with regard to their behaviour but also the motivational and cognitive prerequisites, among which there were such dimensions as technological confidence, professional learning experiences, and institutional support. Also, it acknowledges the presence of the wider structural factors such as digital infrastructure, administrative policies and training opportunities, which indirectly condition the attitude of teachers towards integrating innovative tools.

Based on the guidance provided by TAM, this paper aims to assess the perceived usefulness and practicability of the adoption of AI in the teaching practices of Biology teachers in senior high schools. It offers a systematic guideline for studying the personal beliefs, competencies, and environmental factors that would drive the readiness of teachers to successfully implement AI in science education. The question that the research is going to answer is*: What is the biology teacher's readiness to integrate Artificial Intelligence in their teaching?*

Hypothesis

There is no statistically significant correlation between teachers' preparedness to integrate artificial intelligence into their instructional practices and the perceived advantages of employing AI in education.

METHODOLOGY

The research work utilised the descriptive survey method, which is mostly applied to collect numerical information about a specified group and evaluate their status on some variables of choice [6]. This design was deemed as perfect in exploring the level to which biology teachers in senior high schools of the Volta Region of Ghana are ready to integrate the use of artificial intelligence (AI) tools in their classes. The reason why the Volta Region was selected was that of had both urban and rural schools with different technological infrastructure levels. The researcher used biology teachers selected across the senior high schools in the Volta Region. The study involved 109 teachers who offered a viable coverage of the schools in districts like Ho, Keta, Hohoe, and North Tongu. The selection of these teachers was deliberate to represent as wide a range as possible of access to technology and experience of teaching. The sample was also deemed necessary to allow appropriate calculation of sample size based on the Yamane formula to capture, as it would be the purpose, findings that would effectively represent the general population of the teaching fraternity in the region. The collection of data was based on a self-developed measurement instrument called the Artificial Intelligence Integration Preparedness Scale of Biology Educators (AIIPSBED). The tool was designed through an extensive systematic review of the bodies of literature related to AI in science education. It tried to calculate different variables of teacher preparedness like skills on technology, readiness to offer instructions, availability of infrastructure, as well as their idea on new education technologies. The structured and open-ended questions included in the questionnaire were pilot tested, but not before being critically reviewed by experts, and obtaining a K=0.78, and after it was proven to be reliable and reflected the right content.

Each set of data was coded and analysed with SPSS ver.26 after the data had been collected. Scores were analysed in the form of descriptive statistics, such as means and standard deviations, to serve the purpose of answering research questions and overview of how the trend of preparedness in the area of teachers is distributed across the region. Moreover, the inferential statistics were used to test the research hypothesis. In particular, Pearson Product-Moment Correlation Coefficient (PPMCC) was adopted to determine the relationship between preparedness and variables that include teaching experience, accessibility of ICT resources and participation in professional development programmes, along with their strength and nature. The hypothesis was used to measure a significance level of 0.05 to find out whether any statistically significant correlations were present.

RESULTS AND DISCUSSIONS

Research Question: *What is the biology teacher's preparedness to integrate Artificial Intelligence in their teaching?*

Table 1: Descriptive statistics on the Preparedness of Biology Teachers to Integrate Artificial Intelligence in their Teaching.

ITEMS	M	SD	DECISIONS
I have a good understanding of how artificial intelligence relates to Biology education.	2.61	4.92	Agree
I trust my ability to apply AI tools in teaching Biology lessons.	2.96	15.06	Agree
Learning new AI tools for Biology instruction comes naturally to me.	2.77	9.18	Agree
I feel capable of handling minor technical challenges when using AI in Biology classes.	2.91	12.61	Agree
I am able to assess how well AI tools support student learning in Biology.	2.64	4.57	Agree
I can clearly explain both the strengths and limitations of AI to Biology learners.	3.03	14.93	Agree
I feel ready to design and deliver Biology lessons using AI tools.	3.06	15.99	Agree
I can incorporate AI tools and conventional approaches in the aspect of teaching Biology	2.71	8.52	Agree
I know some AI applications that are useful for Biology instruction.	2.74	13.67	Agree
My knowledge of AI is sufficient for effective use in Biology teaching.	2.40	8.02	Agree
I am confident in using AI to support Biology education.	2.81	10.59	Agree
I am eager to explore and learn about new AI tools for teaching.	2.69	7.09	Agree
I find working with AI tools for Biology instruction to be manageable.	2.39	8.77	Disagree
I have an idea of the ethical issues related to the application of AI in education.	2.93	13.02	Agree
Grand Mean	**2.76**		**Agree**

Table 1 shows the result of the perception of the respondents concerning the willingness of Biology teachers to use carbon type of data in teaching practices. The results suggest that 13 out of the 14 items of the survey were agreed with by the respondents, as indicated by a grand mean score of 2.76, which is an indication of a favourable disposition [23] toward AI integration in Biology teaching. Such a total agreement means that Biology teachers consider themselves moderately ready to use AI technologies in the classroom. Namely, the respondents were confident in such areas as their capacities to use AI-based tools in the classroom (M = 2.96), readiness to plan and implement AI-integrated lessons (M = 3.06), and awareness of the importance of AI in the field of Biology education (M = 2.61). These perceptions concur with another study by [12], which established that the perception of positive self-efficacy by the teachers has a significant effect on intentions to adopt technology-enriched instruction. Moreover, the respondents agreed that they could handle small technical issues (M = 2.91) and evaluate the effects of AI tools on the students (M = 2.64), corresponding with the same case study by [10] who also observed that technical preparedness is more than an excellent indicator of effective integration of technologies in science classroom practice.

There was, however, one question that did not adhere to the rest; the statement, aged between 3 and 4, was not in agreement with the fact that I can find it easy working with AI tools in the teaching of Biology (M = 2.39). It indicates that, although teachers might be basically equipped with theoretical knowledge and look forward to the use of AI, they have more difficulties when it comes to the practical implementation of it. The possible reasons for this gap might be linked to inadequate training, infrastructural limitations, or the lack of practical experiences, which are in line with the results of a study by [15], who pointed to teacher preparedness and resource availability as the drivers of the ineffective usage of educational technology in Ghana.

It should also be mentioned that even though the study also focused on teacher preparedness, it also reflected the lack of access that students have to computers and the internet, which is a critical part of the new machine-based learning environment. The digital tools and access to the internet that support the classroom delivery of instructions are vital in the integration of AI, as in case students could not access what could in turn affect the entire AI efficiency. This concurs with the argument by [9], who pointed out the significance of the availability of technology to both teachers and students for effective digital transformation in education. Further, the high scores of the items associated with knowing the ethical implications (M = 2.93) and the desire to experiment with new AI tools (M = 2.69) prove the progressive nature of Biology teachers. Such receptivity towards innovation confirms the results of [18], who found that continuous professional learning and dynamic teaching practices will play an important role in the use of the potential of emerging educational technologies.

Hypothesis: Teachers' preparedness to implement artificial intelligence into their instructional strategies is not statistically significantly associated with perceived benefits of using artificial intelligence in teaching and learning.

Variable	Correlation coefficient (r)	P	N
Readiness to use AI* Benefits of Using AI	0.995	<0.05	109

The data analysis that investigated the relationship between the readiness of the educator to adopt Artificial Intelligence (AI) in their instructional sessions and their perception of its benefits showed that there was a very strong and significant positive correlation ($r = 0.995$, $p < 0.05$, $N = 109$). This finding implies that the more teachers are prepared and learn about the implementation of AI in the classroom, the more they will realise its pedagogical value. A correlation coefficient value, being close to

+1, points to the strength of this relationship, showing a strong correlation between teacher preparedness and a perception of the value of AI in education. The null hypothesis, suggesting that the two variables are not meaningfully related, was rejected because of the statistical significance of such association. This discovery indicates that the efforts to enhance the readiness of educators, i.e. specific professional development, greater exposure to the AI tools, and institutional support, can be directly related to the adoption of a positive attitude towards AI and the desire of educators to implement it in their work. These observations are similar to the findings of [17], who identified teachers who were more digitally competent and knowledgeable about technological developments as being more willing to acknowledge the practicality of AI and its use in personalised education, automation of automatic repetition, and improvement of assessment systems.

Moreover, such a substantial correlation fits the study conducted by [23], who examined the process of AI introduction to Chinese secondary schools. In their study, they established that educators who felt well-informed about their skills in technology and the institutional support were more open to the use of AI and could define its transformative potential in the education sphere clearly. Similarly, the results of a survey conducted by [16], in Europe, revealed an even more significant role played by the perception of AI usefulness by teachers, as an important MF factor in influencing its implementation, with readiness as a significant mediating factor. These are supported by the results of the current study that show a close interdependency of preparedness and perceived benefits. Also, the findings give empirical evidence to the Technology Acceptance Model (TAM) by Davis 1989 as cited in [19], which posits the perceived usefulness of a technology as a determinant factor in influencing the individual motivation of adopting technology. The situation is no different in the context of AI in education, where having a certain level of value perceived by teachers, AI tools get a better chance at being adopted in advance by their use in the teaching strategies of known teachers.

The high level of correlation that was revealed as the result of this study gives definite support to TAM in the contemporary context of educational technologies. Conversely, other studies with less significant results on the links between readiness and perceived AI benefits tend to cite external limitations on organisational levels [17] (e.g. absence of a technological infrastructure, training opportunities, or institutional inertia). Such constraints are capable of undermining the relationship between preparedness and the perception of usefulness of AI. But within contexts where such barriers are weak, or have been practically controlled, as they could be in the case of the research environment, the connection is remarkably enhanced, and this shows that facilitating conditions are key to successful AI assimilation in education.

CONCLUSIONS

The findings of this study indicate that Biology teachers in the Senior High Schools of the Volta Region of Ghana were quite ready to integrate Artificial Intelligence (AI) into their teaching practices. This readiness cuts across their knowledge or awareness of AI, the technical expertise required to adopt AI and their willingness to embrace such innovations. The teachers were mostly comfortable with their knowledge about AI, possessed an inclination to experiment with the tools based on AI, and could successfully implement the technologies in their classroom lectures. However, there are still several problems, especially those which concern ease of use of technology, resource availability, and lack of infrastructure, that might hinder integration. Notably, the research established a highly intense and statistically meaningful positive correlation ($r = 0.995$, $p < 0.05$) among the preparedness of teachers towards AI usage and the perceived usefulness of AI. This means that improved preparedness and confidence popping up through the teachers are most likely going to be linked with an enhanced understanding of the areas AI has in improving science education. The fact that the null hypothesis is rejected by the study proves the notion that the readiness of teachers can be significantly enhanced to help expand the implementation of AI and eventually contribute to the quality of instruction run by teachers and the increased engagement of students.

These findings substantiate the tenets of the Technology Acceptance Model (TAM) that postulates that the choices of the educators to use new technologies are more motivated by their thoughts of utility and convenience. These conclusions are also supported by the studies of other researchers like [23];[16] and confirm the idea that the readiness of teachers, besides being the condition of a positive experience of educational technologies, is also its outcome. However, certain areas of concern have never been addressed and still are extraordinarily troublesome, like the lack of technical support, ethical challenges, and differences in access to digital resources in urban and rural schools that need to be addressed tactically.

RECOMMENDATIONS

1. The Regional Directorate of Ghana Education Service (GES) ought to institutionalise in-service training that pays much attention to AI literacy, AI pedagogical uses and ethical issues in the use of AI.

2. Curriculum developers and policy-makers ought to incorporate modules of AI in pre-service teacher education and the curricula of secondary schools. This will make teachers and students acquire the basic knowledge they need of AI as they prepare to carry out an educational life on a technology highway.
3. The Regional Directorate of Ghana Education Service and school authorities should focus on providing sufficient digital infrastructure, such as stable internet connection, access to computers and artificial intelligence programs and services, as well as technical support, especially in rural schools that have little to no such resources.

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