



Does Teaching Experience Matter? Biology Teachers' Awareness, Readiness, and Utilization of AI-Powered Virtual Laboratories in Akwa Ibom State

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Abstract

Artificial Intelligence-powered virtual laboratories (AI-VLs) are emerging as digital complements to physical laboratory experiences, particularly where physical laboratory resources are inadequate. This study examined whether years of teaching experience significantly influences Biology teachers' awareness, readiness, and utilization of AI-VLs in public secondary schools in Akwa Ibom State, Nigeria. A descriptive survey design with a structured-observation component was used. From a population of 1,147 Biology teachers, 288 were selected through multistage sampling from 78 schools. Data were collected with two researcher-developed instruments: the AI-Powered Virtual Laboratory Acceptance Questionnaire (AIVLAQ) and the AI-Powered Virtual Laboratory Readiness and Utilization Observation Checklist (AIVLROC). Three specialists established content validity. Pilot reliability coefficients were .88 (Cronbach's alpha) for awareness and .89 and .83 (KR-20) for readiness and utilization. Means, standard deviations, one-way ANOVA, and eta squared were used. The 11–20-year group recorded the highest awareness mean ($M = 17.83$), the 0–10-year group the highest readiness mean ($M = 13.37$), and the above-20-year group the highest utilization mean ($M = 4.64$). Differences were not significant for awareness, $F(2, 285) = 0.31$, $p = .737$, $\eta^2 = .0021$; readiness, $F(2, 285) = 1.19$, $p = .307$, $\eta^2 = .00825$; or utilization, $F(2, 285) = 0.38$, $p = .682$, $\eta^2 = .00268$. Thus, teaching experience alone may not significantly influence awareness, readiness, and utilization of AI-VL. The findings imply that career length alone is insufficient for understanding these outcomes. Inclusive, needs-based technology-pedagogical preparation and improved electricity, devices, connectivity, technical support, and platform access are recommended.

Keywords: AI-powered virtual laboratories, Biology teachers, teaching experience, awareness, readiness, utilization

Introduction

Artificial Intelligence-powered virtual laboratories (AI-VLs) is an emerging educational technology that integrate simulated laboratory environments with artificial intelligence to provide adaptive, interactive, and data-informed instructional support. Unlike conventional laboratories, AI-VLs imitate physical laboratory procedures in digital environments, incorporate intelligent features such as learner monitoring, adaptive guidance, personalized learning pathways, and immediate feedback (Sapriati et al., 2023; Qawaqneh et al., 2023). They therefore have the potential to move virtual laboratory experiences beyond simple simulation toward more responsive and learner-centred instructional environments.

The growing interest in AI-VLs is partly associated with their potential to address limitations affecting access to practical learning. Virtual laboratories can provide repeatable experimentation, allow learners to manipulate variables, observe outcomes, and reduce reliance on physical equipment and consumables (Achuthan et al., 2018; Cruz et al., 2025). The integration of artificial intelligence may further enhance these benefits by adapting instructional support to learners' performance. Studies have reported that virtual laboratory experiences can support the understanding of difficult Biology concepts (Byukusenge et al., 2022; Hendratmoko et al., 2023). However, the availability of these technologies does not automatically translate into their meaningful use in schools. Teachers remain central to technology

integration because they determine whether, when, and how emerging technologies are incorporated into instructional practice.

Three constructs are particularly relevant to understanding teachers' integration of educational technology: awareness, readiness, and utilization (Mishra & Koehler, 2006; Venkatesh et al., 2003). Awareness concerns teachers' knowledge of a technology and its probable instructional value; readiness mirrors their preparedness in terms of skills, attitudes, and availability of school-based supporting conditions; while utilization concerns the actual use of the technology in instructional practice (Kranz et al., 2023). These constructs are related because awareness can provide the informational basis for readiness, readiness can create the capability and willingness to use, and utilization represents the actual enactment of that capability in instructional practice. However, they are analytically distinct and should not be treated as interchangeable or as an automatic sequence. For instance, a teacher may be aware of AI-VLs without having the skills or confidence required to use them, while a teacher who is ready to use the technology may still be unable to do so because of inadequate infrastructure or institutional support. So, awareness and readiness do not necessarily progress into utilization (Achuthan et al., 2018). In resource-constrained settings, unfortunate internet connectivity, unreliable electricity, inadequate training, and limited institutional support may further constrain technology use (Alnagrat et al., 2023; Nuru & Adamu, 2025).

One teacher characteristic that may influence awareness, readiness, and utilization of educational technology is years of teaching experience. Teaching experience is associated with accrued pedagogical knowledge, classroom management skills, subject-matter experience, and familiarity with different instructional approaches. Consequently, more experienced teachers may possess stronger pedagogical and content knowledge that could help them determine how AI-VLs can be incorporated into Biology instruction. However, teaching experience may also be associated with greater reliance on established instructional practices, whereas educators having less years of practise may be more exposed to digital technologies and consequently adapt more readily to emerging AI-based tools.

The link between teaching experience and teachers' awareness, readiness, and utilization of AI-VLs is therefore not straightforward. In this study, awareness was operationalized as the extent to which a teacher recognized AI-VLs, understood their basic

functions, and perceived their relevance to Biology teaching. Readiness was operationalized as observable preparedness to use an AI-VL, including the ability to access the platform, navigate core functions, select an appropriate activity, connect the activity with instruction, and the presence of school-level enabling conditions. Utilization was operationalized as observable performance of an AI-VL-supported instructional activity, including launching an activity, manipulating relevant variables, interpreting outputs, and using the platform in a manner linked to a Biology objective. These variables though related as earlier enunciated, remain distinct because awareness does not guarantee skills or confidence, readiness does not remove infrastructural barriers, and actual utilization depends on opportunities to use the technology. Thus, teaching experience may strengthen pedagogical and content knowledge, but it does not necessarily produce the technological knowledge required for effective AI-VL use. Less-experienced teachers may have greater exposure to contemporary digital tools, whereas more-experienced teachers may have stronger classroom and subject-matter knowledge with which to judge their instructional value.

The Technological Pedagogical Content Knowledge (TPACK) framework provides the first theoretical anchor for this study. TPACK explains the knowledge base required for effective technology integration: technological knowledge (how the AI-VL works), pedagogical knowledge (how to organize learning), and content knowledge (what Biology concept or practical skill is being taught), together with their intersections (Hsu, 2016; Shambare & Jita, 2024). Applied to AI-VLs, technological knowledge concerns operating the virtual laboratory and interpreting its intelligent features; pedagogical knowledge concerns selecting, sequencing, and facilitating activities; and content knowledge concerns connecting the activity to Biology concepts and practical skills. The framework is relevant because years of teaching experience may contribute to pedagogical and content knowledge without necessarily providing the technological knowledge or integrated TPACK required for AI-VL use. Shambare and Jita (2024), for example, found stronger life-sciences teachers' content and pedagogical knowledge than their technology-related TPACK domains in rural schools, suggesting that subject experience alone may not ensure readiness or utilization.

The Unified Theory of Acceptance and Use of Technology (UTAUT) provides the second theoretical anchor and explains the conditions under

which teachers are likely to use a technology (Venkatesh et al., 2003; Kittinger & Law, 2024; Feng et al., 2025). Its constructs of performance expectancy, effort expectancy, social influence, and facilitating conditions are relevant to the present variables. Awareness is likely to be shaped partly by whether teachers understand what AI-VLs can do and perceive them as relevant; readiness is likely to reflect perceived usefulness, ease of use, confidence, and social support; and utilization is most directly dependent on facilitating conditions such as devices, electricity, connectivity, technical assistance, and access to an appropriate platform. UTAUT therefore complements TPACK: TPACK explains the knowledge needed to connect technology with Biology pedagogy and content, while UTAUT explains how perceived value, effort, social influence, and school conditions can enable or constrain the use of that knowledge. Together, the frameworks predict that teaching experience alone may be a weak influencer when teachers operate within similar institutional conditions.

Empirical findings on the three variables are mixed. Regarding awareness, Güneşli et al. (2024) found that teachers' overall AI awareness was slightly above the midpoint and that age, gender, education level, school type, and income did not significantly influence awareness. Their finding supports the possibility that career length may not determine awareness, although their result also showed that practical knowledge and attitudes were more important for classroom use than theoretical knowledge alone. In contrast, Bakhadirov et al. (2024) reported age-related differences in teachers' use of AI for instructional purposes, suggesting that exposure to contemporary digital environments may advantage some less-experienced teachers. Also, Nuru and Adamu (2025) found no significant influence of teaching experience on AI awareness and utilization. These contrasting findings justify examining awareness and utilization separately rather than treating one as evidence of the other. Evidence on readiness also emphasizes preparation rather than career length. In a Nigerian study of 368 in-service teachers, Ayanwale et al. (2022) found that confidence in teaching AI predicted teachers' intention to teach it, while perceived relevance strongly predicted readiness; anxiety did not significantly predict intention. The implication is that professional knowledge, confidence, and perceived relevance may matter more for readiness than years of service. Findings from virtual-laboratory research point in the same direction: teachers may value virtual laboratories while still requiring stronger technology-related knowledge

and support for meaningful utilization (Shambare & Jita, 2024).

The need for this investigation is especially defensible in Akwa Ibom State, Nigeria. Akwa Ibom has 31 local government areas and combines urban centres with rural and coastal communities (Akwa Ibom State Government, n.d.). These differences matter because AI-VL utilization depends not only on teacher characteristics but also on the availability of electricity, internet connectivity, devices, technical assistance, and school-level support. Local evidence has already shown that ICT availability, teachers' use of ICT, and teachers' proficiency are important issues in Akwa Ibom secondary schools (Akpabio & Ogiriki, 2017). However, that evidence concerns general ICT, not Biology teachers' awareness, readiness, and observed utilization of AI-powered virtual laboratories. The local literature therefore provides a reason to investigate the state, but it does not answer the present question. Despite increasing interest in AI-driven educational technologies and virtual laboratory environments, empirical evidence concerning secondary-school Biology teachers' three dimensions of engagement remains limited in Nigeria and is especially scarce for Akwa Ibom. Existing studies have focused substantially on students' achievement, motivation, retention, and learning outcomes, or on broad AI/ICT use, with comparatively less attention to teachers' awareness, readiness, and actual utilization of AI-VLs. Whether years of teaching experience influences these dimensions in Akwa Ibom consequently remains an open empirical question. If influences exist, professional development may need to be differentiated by teachers' demonstrated needs; if influences are negligible, broader interventions addressing TPACK development and UTAUT facilitating conditions may be more appropriate. Therefore, this study examined whether Biology teachers at different stages of their careers differ significantly in their awareness, readiness, and utilization of AI-powered virtual laboratories in public secondary schools in Akwa Ibom State.

Research Questions

1. What is the level of Biology teachers' awareness of AI-VLs based on their years of teaching experiences?
2. What is the level of Biology teachers' readiness to use AI-VLs based on their years of teaching experiences?
3. What is the level of Biology teachers' utilization of AI-VLs based on their years of teaching experiences?

Hypotheses

The following null hypotheses were tested at the 0.05 level of significance:

H₀₁: There is no statistically significant difference in Biology teachers' mean awareness scores regarding AI-VL based on years of teaching experience.

H₀₂: There is no statistically significant difference in Biology teachers' mean readiness scores regarding AI-VL based on years of teaching experience.

H₀₃: There is no statistically significant difference in Biology teachers' mean utilization scores regarding AI-VL based on years of teaching experience.

Methodology

Design and Setting

A descriptive survey design with a structured-observation component was adopted. This design was appropriate because the study sought to describe and compare awareness, readiness, and utilization as they existed naturally across experience groups; neither years of teaching experience nor access to AI-VLs was manipulated. The study was conducted in Akwa Ibom State, Nigeria, across the state's 31 local government areas due to unavailability of empirical evidence on Biology teachers' awareness, readiness, and utilization of AI-VLs in the state. The target population consisted of 1,147 Biology teachers in 244 public secondary schools at the time of the study. Biology teachers were selected because they are the personnel responsible for translating the practical Biology curriculum into classroom and laboratory experiences.

Sampling Procedure

A multistage sampling procedure was used. First, the Local Education Committees (LECs) in Akwa Ibom State were stratified into urban and rural categories. Five urban LECs and eight rural LECs were selected by simple random sampling using balloting without replacement. Second, six secondary schools were randomly selected from each selected LEC. This produced 30 urban schools and 48 rural schools, or 78 participating schools. Third, all Biology teachers available in the selected rural schools were included. In the urban LECs, where a school had more than five Biology teachers, five were selected by simple random sampling after stratification by gender, years of teaching experience, and academic qualification; where there were five or fewer Biology teachers, all were included. The procedure yielded 288 teachers. The

final respondents were grouped as early career (0–10 years, $n = 104$), mid-career (11–20 years, $n = 116$), and late career (above 20 years, $n = 68$). This classification was adapted and informed by teacher-career literature, particularly Nguyen's (2023) analysis of professional life phases. This procedure ensured representation of urban and rural settings while reducing the risk that one demographic subgroup would dominate the urban sample.

Instruments and Operationalization

Two researcher-developed instruments were used. They were developed from the operational definitions above and informed by the TPACK and UTAUT constructs. The AIVLAQ was separated into two sections. Section A for collecting demographic details of respondent including years of teaching experience and section B contained eight awareness items rated Very High Extent (4), High Extent (3), Low Extent (2), and Very Low Extent (1). The AIVLROC was used to assess teachers' observed readiness and utilization of AI-VLs. The instrument was completed by the researcher and trained research assistants as participants performed specified AI-VL tasks. Readiness was operationalised as the observable capacity and preparedness to interact with the AI-VL and demonstrate appropriate task-related attitudes. The checklist also recorded the presence of enabling conditions, including electricity, functional devices, internet connectivity, and technical support. Each criterion was scored dichotomously: "Yes" (1) when the behaviour or condition was observed and "No" (0) when it was not observed. The readiness score was obtained by summing the relevant item scores; hence, the total score represented the extent to which the participant demonstrated the specified readiness indicators. It contained 36 dichotomous items, divided into readiness and utilization clusters.

Validity and Reliability

Three experts—two in Biology Education and one in Measurement and Evaluation from the Department of Science Education, Michael Okpara University of Agriculture, Umudike, reviewed the instruments. Their recommendations were incorporated before the pilot study. A pilot test involved 30 Biology teachers in public secondary schools in Abia State who were not part of the main sample. Cronbach's alpha was used for the multi-point AIVLAQ items and produced a coefficient of .88. Cronbach's alpha was appropriate because the instrument comprised multiple Likert-type items. KR-20 was used for the readiness and utilization sections of the AIVLROC because those items were

scored dichotomously (0/1); KR-20 is the appropriate internal-consistency estimate for a binary-scored scale and yielded coefficients of .89 and .83, respectively. The coefficients exceeded .70 and indicated satisfactory internal consistency. The assistants were trained with the administration guide and practice cases; disagreements during practice were discussed and resolved before fieldwork.

Data Collection and Analysis

The researcher and three trained assistants administered the instruments. Each teacher was

observed while performing tasks using AI-VL platform, after which the AIVLAQ was completed and retrieved. Completed instruments were checked for missing responses at the point of collection. Data were analysed using IBM SPSS statistics version 25. Means and standard deviations described the three experience groups. One-way ANOVA tested each null hypothesis at $\alpha = .05$. Eta squared ($\eta^2 = SS_{\text{between}}/SS_{\text{total}}$) was reported to show the magnitude of the group effect. A p-value $\leq .05$ led to rejection of the relevant null hypothesis; otherwise, it was not rejected.

Results

Research Questions 1 and Hypothesis 1

Table 1: Mean Awareness Scores and One-Way ANOVA of Biology Teachers Based on Years of Teaching Experience

Years of teaching experience	N	Mean	SD	Source	SS	df	MS	F	p	η^2
Early (0–10 years)	104	17.74	5.13	Between Groups	16.64	2	8.32	0.31	.737	.0021
Mid (11–20 years)	116	17.83	5.48	Within Groups	7778.03	285	27.29			
Late (above 20 years)	68	17.23	4.90	Total	7794.66	287				

Note. $\eta^2 = .0021$, approximately 0.21% of the variance in awareness scores.

Table 1 shows that the mid-career group recorded the highest awareness mean ($M = 17.83$, $SD = 5.48$), but the difference was not statistically significant, $F(2, 285) = 0.31$, $p = .737$. Since the p-

value was greater than .05, H_{01} was not rejected. The eta-squared value of .0021 indicates a negligible effect: experience group accounted for approximately 0.21% of the variance in awareness.

Research Questions 2 and Hypothesis 2

Table 2: Mean Readiness Scores and One-Way ANOVA of Biology Teachers Based on Years of Teaching Experience

Years of teaching experience	N	Mean	SD	Source	SS	df	MS	F	P	η^2
Early (0–10 years)	104	13.37	2.44	Between Groups	13.74	2	6.87	1.19	.307	.00825
Mid (11–20 years)	116	13.03	2.20	Within Groups	1651.70	285	5.80			
Late (20 years and above)	68	12.82	2.68	Total	1665.44	287				

Note. $\eta^2 = .00825$, approximately 0.83% of the variance in readiness scores.

Table 2 shows that Biology teachers in the early-career group had the highest readiness mean

($M = 13.37$, $SD = 2.44$), but the group difference was not statistically significant, $F(2, 285) = 1.19$, $p =$

.307, which is greater than 0.05, H02 was not rejected. The eta-squared value of .00825 indicates a

very small effect: experience group explained approximately 0.83% of readiness-score variance.

Research Questions 3 and Hypothesis 3

Table 3: Mean Utilization Scores and One-Way ANOVA of Biology Teachers Based on Years of Teaching Experience

Years of teaching experience	N	Mean	SD	Source	SS	df	MS	F	p	η^2
Early (0–10 years)	104	4.48	1.99	Between Groups	2.56	2	1.28	0.38	.682	00268
Mid (11–20 years)	116	4.39	1.73	Within Groups	952.11	285	3.34			
Late (above 20 years)	68	4.64	1.73	Total	954.68	287				

Note. $\eta^2 = .00268$, approximately 0.27% of the variance in utilization scores.

Table 3 shows that Biology teachers in the late-career group recorded the highest utilization mean ($M = 4.64$, $SD = 1.73$), but the difference was not statistically significant, $F(2, 285) = 0.38$, $p = .682$. H03 was not rejected. The eta-squared value of .00268 indicates a negligible effect: experience group explained approximately 0.27% of utilization-score variance.

Discussion of Findings

The study found no statistically significant difference among early-, mid-, and late-career teachers in awareness, readiness, or utilization of AI-VLs. More importantly, the effect sizes were negligible or very small. Experience accounted for approximately 0.21% of awareness variance, 0.83% of readiness variance, and 0.27% of utilization variance. These values show that the non-significant results are not merely a consequence of an arbitrary p-value threshold; teaching experience made little practical contribution to explaining differences in the three measured outcomes.

The awareness result suggests that awareness of an emerging technology is not accumulated automatically through years in the profession. AI-VLs are relatively new, and exposure may depend more on professional development, personal digital use, online communities, and access to information than on career length. The result is consistent with Nuru and Adamu (2025), who found no significant influence of teaching experience on AI awareness and utilization. The result however differs from reports that younger teachers adopt AI more readily (Bakhadirov et al., 2024; Güneşli et al., 2024). The divergence supports a context-sensitive

rather than universal account of career-stage differences.

The readiness finding is compatible with TPACK perspective that effective technology adoption must interweave technology knowledge, pedagogical knowledge, and content knowledge (Hsu, 2024; Shambare & Jita, 2024). Years of experience may support pedagogical and content knowledge, but readiness to use an AI-VL also requires technological knowledge and the ability to combine all three domains in a Biology lesson. A less-experienced teacher may have recent exposure to digital tools but limited classroom experience; a more-experienced teacher may have strong pedagogical judgment but less opportunity to learn AI-VL functions. These countervailing resources can produce similar readiness levels across groups.

The finding also supports the complementary interpretation offered by UTAUT. According to UTAUT, technology use is stimulated by performance expectancy, effort required, social influence, and enabling conditions (Kittinger & Law, 2024; Feng et al., 2025). These factors may affect teachers across different experience levels. For example, an experienced teacher may be highly willing to use AI-VLs but lack the necessary infrastructure or training, while an early-career teacher may be technologically confident but face the same institutional limitations. So, common facilitating conditions may reduce the importance of teaching experience as an explanatory variable.

The result on utilization demonstrates that longer teaching experience did not translate into significantly greater utilization of AI-VLs. This finding supports Nuru and Adamu (2025) who

recorded no significant influence of teaching experience on utilization. Interestingly, the late-career group recorded the highest utilization mean, contrary to the assumption that teachers with fewer years of experience would necessarily be more likely to use emerging technologies (Bakhadirov et al., 2024; Güneyli et al., 2024). This result is with the UTAUT's facilitating-conditions construct. Even a willing and experienced teacher may not use an AI-VL when electricity, devices, connectivity, technical support, or institutional access are unreliable. Conversely, a less-experienced teacher may use the technology when these conditions and supports are present. The late-career group had the highest descriptive utilization mean, which cautions against portraying experienced teachers as inherently resistant to innovation; however, its negligible effect size shows that the pattern is not consistent enough to establish experience as a meaningful determinant.

Conclusion

Years of teaching experience did not significantly influence Biology teachers' awareness, readiness, or utilization of AI-VLs in Akwa Ibom State. The very small eta-squared values further indicate that career length explained little practical variance. Therefore, the results do not support the assumption that either early, mid, or late teaching experience inherently gives teachers an advantage in AI-VL awareness, readiness, or utilization.

Educational Implications

The educational implication is that the Ministry of Education and school authorities should provide inclusive, needs-based-technological-pedagogical professional development for teachers at all career stages. Training should integrate AI-VL operation with specific Biology topics, inquiry, practical skills, assessment, and lesson objectives. It should also include opportunities for guided practice and peer support, because TPACK is developed through the integration of technology, pedagogy, and content rather than through generic exposure to an application. In UTAUT terms, schools should strengthen facilitating conditions through reliable electricity, suitable devices, connectivity, technical assistance, and access to approved platforms. Curriculum planners should identify where AI-VL activities complement, not replace, physical practical work.

Recommendations

Based on the findings of the study, the following recommendations are made.

1. The Akwa Ibom State Ministry of Education should conduct a needs assessment and organize recurring, hands-on AI-VL professional development for Biology teachers across experience groups.
2. Training should be organized around Biology topics and observable TPACK competencies, not around years of service.
3. School authorities should improve facilitating conditions, including electricity, devices, connectivity, technical support, and responsible access to AI-VL platforms.
4. Curriculum planners should explicitly identify appropriate AI-VL activities within Biology curriculum and lesson guides so that teachers can connect virtual laboratory experiences with specific content, practical skills, and learning outcomes.

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