Vol. 2, No. 1, 2026 - Kwararafa University Journal of Multidisciplinary Research and Innovation
Pub. Link: https://aa.unij.co.uk/index.php/kujmri/issue/view/6 - E- ISSN: 3156-5492 | P- ISSN: 3156-5514

Digital Pedagogy Resources in Chemistry Education: Awareness, Utilisation, and Demographic Correlates among Secondary School Teachers in Kwara State, Nigeria

OLAWALE Akinmide Christopher
Department of Science and Technology Education
Faculty of Education, University of Ibadan, Oyo State, Nigeria
ac.olawale@ui.edu.ng / +2348038310036
https://orcid.org/0000-0001-9735-438X

KEHINDE David Deji
Federal University Oye-Ekiti Oye-Ekiti, Nigeria
didikehinde@gmail.com /+2348062221826

OLUWATIMILEHIN Ojochenemi Joy
Department of Curriculum and Instruction
Federal College of Education, Okenne, Kogi State
anupelumy@gmail.com / +2347068454235

GABRIEL Deborah Oluwatoyin
Department of Chemistry
Faculty of Pure and Applied Science
Kwara State University Malete, Nigeria
ajayioluwatoyin62@gmail.com / +2347039612057

DOI : https://doi.org/10.5281/zenodo.22917513

Abstract

Despite growing policy interest in digital pedagogy, chemistry teachers in Nigerian secondary schools appear to have limited awareness and use of available online digital instructional resources. This study investigated secondary school chemistry teachers' awareness and utilisation of online chemistry instructional resources in Kwara State, Nigeria, and examined whether gender, teaching experience, and professional qualification were associated with these variables. The study adopted a descriptive survey design and covered the total population of 234 chemistry teachers through a census approach. Data were collected using the Online Chemistry Instructional Resources Questionnaire (OCIRQ), which assessed awareness and utilisation of 46 online resources on separate three-point scales. Descriptive statistics were used to answer the first two research questions, while chi-square tests of independence were used to examine associations between demographic characteristics and the categorical distributions of awareness and utilisation. Of the 46 resources examined, only one recorded a mean awareness score above 2.0 in the high-awareness category, while 15 met or exceeded the benchmark for adequate awareness. For utilisation, 12 resources met or exceeded the 2.0 benchmark, although none was frequently

Vol. 2, No. 1, 2026 - Kwararafa University Journal of Multidisciplinary Research and Innovation
Pub. Link: https://aa.unij.co.uk/index.php/kujmri/issue/view/6 - E- ISSN: 3156-5492 | P- ISSN: 3156-5514

used by a majority of teachers. The chi-square analyses revealed no statistically significant associations between gender, teaching experience, or professional qualification and either awareness or utilisation ($p > .05$). The findings indicate that the observed limitations were not significantly differentiated across the demographic groups examined. The study therefore recommends coordinated attention to digital infrastructure, TPACK-oriented professional development, subject-specific resource curation, and institutional support.

Keywords: digital pedagogy, awareness, utilisation, online resources, chemistry education

1. Introduction

The relationship between technology and education has become increasingly consequential in contemporary teaching and learning. Digital resources can broaden access to instructional materials and create opportunities for interactive and learner-centred activities. In Nigerian schools, however, the availability and use of ICT resources remain uneven. Evidence from secondary-school settings indicates that teachers may have limited exposure to ICT facilities and that inadequate infrastructure, including electricity and equipment, can constrain classroom integration (Menkiti & Menkiti, 2013). This context is particularly important in science education, where appropriate digital tools may support the representation and exploration of concepts that are difficult to demonstrate through conventional instruction.

Chemistry presents particular instructional challenges because learners must reason across multiple levels of representation, including observable phenomena, submicroscopic molecular processes, and symbolic representations such as chemical equations. Molecular-modelling environments can help learners connect representations and develop spatial understanding; Dori and Barak (2001), for example, examined virtual and physical molecular modelling as tools for fostering model perception and spatial understanding. Virtual laboratories and related digital environments may also provide opportunities to engage with practical concepts when physical laboratory access is constrained (Suprapto *et al*., 2021).

Despite these possibilities, the availability of digital resources does not necessarily translate into classroom use. Nigerian studies have identified limitations in ICT availability and exposure among teachers, as well as teacher-level and knowledge-related factors affecting technology integration (Ifinedo *et al*., 2020; Menkiti & Menkiti, 2013). In Nigerian secondary schools, professionally trained teachers have also been reported to differ from non-professionally trained teachers in ICT instructional-material utilisation competencies (Ololube, 2006). These findings suggest that infrastructure, professional knowledge, and teacher preparedness may interact in shaping technology integration. The present study therefore examines not only whether online chemistry resources are available in the wider digital environment but also the extent to which teachers are aware of and utilise specific resources.

This study examines secondary school chemistry teachers' awareness and utilisation of online instructional resources in Kwara State, Nigeria, with particular attention to whether demographic characteristics gender, teaching experience, and professional qualification are associated with these variables. The study adopts the TPACK framework (Mishra & Koehler, 2006) to provide a conceptual basis for understanding technology integration and employs a census-based descriptive

Vol. 2, No. 1, 2026 - Kwararafa University Journal of Multidisciplinary Research and Innovation
Pub. Link: https://aa.unij.co.uk/index.php/kujmri/issue/view/6 - E- ISSN: 3156-5492 | P- ISSN: 3156-5514

survey design with chi-square inferential statistics. The purpose is to document the observed pattern and examine whether it is distributed differently across demographic groups, rather than to infer causal effects.

1.1 Statement of the Problem

Although Nigerian education policy emphasises digital inclusion, secondary school chemistry instruction remains predominantly conventional, with limited adoption of freely available online resources such as interactive periodic tables, molecular visualisation applications, and virtual laboratories. Existing literature has largely focused on general ICT use, leaving limited evidence on teachers' awareness and utilisation of subject-specific chemistry resources. In addition, the extent to which teacher characteristics, including gender, teaching experience, and professional qualification, are associated with technology adoption in a context characterised by rural–urban variation and infrastructural constraints, such as Kwara State, remains insufficiently established. Addressing these gaps is important for distinguishing systemic constraints from differences that may be associated with particular groups of teachers and for designing appropriately targeted interventions.

1.2 Research Objectives

The objectives of the study were to:

1. determine the level of awareness of online chemistry instructional resources among chemistry teachers in Kwara State, Nigeria;
2. determine the level of utilisation of online chemistry instructional resources among these teachers; and
3. examine whether gender, teaching experience, and professional qualification are significantly associated with teachers' awareness and utilisation of online chemistry instructional resources.

1.3 Research Questions

This study was guided by the following research questions:

1. What is the level of awareness of online chemistry instructional resources among chemistry teachers in Kwara State, Nigeria?
2. What is the level of utilisation of online chemistry instructional resources among these teachers?
3. Are gender, teaching experience, and professional qualification significantly associated with teachers' awareness and utilisation of online chemistry instructional resources?

Vol. 2, No. 1, 2026 - Kwararafa University Journal of Multidisciplinary Research and Innovation
Pub. Link: https://aa.unij.co.uk/index.php/kujmri/issue/view/6 - E- ISSN: 3156-5492 | P- ISSN: 3156-5514

1.4 Research Hypotheses

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

H_{01}: There is no statistically significant association between gender and teachers' awareness of online chemistry instructional resources.

H_{02}: There is no statistically significant association between gender and teachers' utilisation of online chemistry instructional resources.

H_{03}: There is no statistically significant association between teaching experience and teachers' awareness of online chemistry instructional resources.

H_{04}: There is no statistically significant association between teaching experience and teachers' utilisation of online chemistry instructional resources.

H_{05}: There is no statistically significant association between professional qualification and teachers' awareness of online chemistry instructional resources.

H_{06}: There is no statistically significant association between professional qualification and teachers' utilisation of online chemistry instructional resources.

2. Literature Review

2.1 Benefits of Digital Technologies in Chemistry Education

Evidence supporting digital technology integration in science education includes research on virtual laboratories and molecular modelling. Suprapto *et al*. (2021), in a systematic review of virtual laboratories in science education, identified evidence of their usefulness for learning and teaching, while Dori and Barak (2001) examined virtual and physical molecular modelling in relation to students' model perception and spatial understanding. These studies support the pedagogical potential of particular digital environments, but they do not by themselves establish that such resources are routinely used by Nigerian secondary-school chemistry teachers.

Digital tools may also provide practical alternatives or complements where physical laboratory resources are limited. Virtual environments can allow learners to interact with representations and simulated procedures without some of the material, safety, and equipment constraints associated with physical experiments (Suprapto *et al*., 2021). However, the extent to which these affordances are realised depends on access, teacher competence, and the pedagogical context; they should therefore be treated as potential advantages rather than assumed outcomes of simply providing digital resources.

Technology integration may also support engagement and learning behaviour under appropriate instructional conditions. Hwang *et al*. (2021), for example, reported that a social-regulation-based online learning framework improved learning achievement and learning motivation and stimulated more positive learning behaviours in a high-school mathematics context. Tondeur *et al*. (2017), in a systematic review, further showed that teachers' pedagogical beliefs and contextual conditions are relevant to technology use. These findings support the broader proposition that technology integration is pedagogically contingent rather than an automatic consequence of access to digital tools.

Vol. 2, No. 1, 2026 - Kwararafa University Journal of Multidisciplinary Research and Innovation
Pub. Link: https://aa.unij.co.uk/index.php/kujmri/issue/view/6 - E- ISSN: 3156-5492 | P- ISSN: 3156-5514

2.2 Barriers to Technology Adoption in Nigeria

Infrastructure and access remain important considerations in Nigerian technology integration. Menkiti and Menkiti (2013), in a study of secondary-school teachers in Enugu Urban, reported limited availability and exposure to ICT facilities and identified infrastructure, including electricity, as an important area for improvement. Ifinedo *et al*. (2020), studying Nigerian teacher educators, likewise found that technological knowledge and ICT-pedagogical practice were important in explaining technology integration and highlighted implications for professional training. Together, these studies indicate that both enabling conditions and teacher-level knowledge may matter, although the present study did not directly measure either infrastructure or TPACK.

In secondary-school contexts, evidence also points to limited awareness and utilisation of digital resources. Omiko (2016) examined the availability and use of instructional materials among secondary-school chemistry teachers in Nigeria, while Ugwu and Ohimekpen (2015) reported limited awareness and use of e-learning resources among secondary-school teachers in Yobe State. These studies support the relevance of examining awareness and utilisation separately. They do not, however, justify treating inadequate use as a single national pattern; the present study is confined to chemistry teachers in Kwara State.

Professional learning is another potential enabling condition. Ifinedo *et al*. (2020) identified implications for strategic and practical professional training in improving Nigerian teacher educators' technology integration, while Ololube (2006) reported differences in ICT instructional-material utilisation competencies between professionally trained and non-professionally trained teachers. These findings suggest that professional preparation may matter, but they do not establish that qualification alone determines technology use. The present study therefore treats professional qualification as an empirical demographic variable to be tested rather than as an assumed determinant.

2.3 Teacher Characteristics and Use of Technology

Research on teacher characteristics and technology use has produced mixed findings. Gorder (2008) found no differences in technology use and integration based on gender, age, teaching experience, content area, or educational level in the study examined, although grade-level differences were observed. Egede (2021) similarly found no statistically significant overall gender difference in student-teachers' readiness to use ICT, while Fakomogbon *et al*. (2015) examined gender in relation to lecturers' awareness and utilisation of instructional media in Nigerian colleges of education. The mixed evidence supports testing demographic associations in the present context rather than assuming that gender is a consistent predictor.

Teaching experience also warrants empirical examination rather than an assumed directional interpretation. Gorder (2008) reported no difference in technology use and integration based on teaching experience, whereas Ifinedo *et al*. (2020) incorporated teacher characteristics alongside knowledge constructs and ICT practices in explaining technology integration among Nigerian teacher educators. These findings suggest that experience should be considered alongside other professional and contextual factors rather than treated as a sufficient explanation for technology use.

Vol. 2, No. 1, 2026 - Kwararafa University Journal of Multidisciplinary Research and Innovation
Pub. Link: https://aa.unij.co.uk/index.php/kujmri/issue/view/6 - E- ISSN: 3156-5492 | P- ISSN: 3156-5514

Professional qualification may provide another relevant dimension because formal teacher preparation can be associated with ICT-related competencies. Ololube (2006) reported significant differences in ICT instructional-material utilisation competencies between professionally trained and non-professionally trained teachers in Nigerian secondary schools. However, this does not establish that qualification necessarily produces higher awareness or utilisation of subject-specific online chemistry resources. The present study therefore tests whether professional qualification is associated with the observed categorical distributions of awareness and utilisation.

3. Theoretical Framework

3.1 Technology Integration and TPACK

The theoretical framework for this study is Technological Pedagogical Content Knowledge (TPACK), introduced by Mishra and Koehler (2006) as an extension of Shulman's (1987) concept of pedagogical content knowledge. TPACK proposes that effective technology integration cannot be reduced to technical competence alone; rather, it involves the interaction of technological, pedagogical, and content knowledge. A teacher may know how to operate a digital tool but still be unable to use it effectively if the tool is not aligned with pedagogical purposes and disciplinary content. This framework is therefore appropriate for examining teachers' awareness and utilisation of online chemistry resources because the pedagogical value of a resource depends partly on teachers' capacity to select and integrate it appropriately.

In chemistry education, online instructional materials can be viewed as technological resources whose educational value depends on how they are selected, interpreted, and integrated with subject content and pedagogy. Jang and Chen (2010) demonstrated how a transformative model combining technology integration and peer coaching could support the development of TPACK among pre-service science teachers. The study therefore provides a more direct basis for linking TPACK-oriented professional learning to technology integration than the previously cited source. In the present study, awareness and utilisation are treated as observable indicators of engagement with digital resources, not as direct measures of TPACK itself.

This perspective is consistent with constructivist views of learning, in which technology can function not merely as a source of information but as a cognitive tool that supports active knowledge construction (Jonassen *et al*., 2008). From this perspective, awareness and utilisation may provide useful descriptive indicators of teachers' engagement with digital resources. Low levels of awareness and utilisation should not, however, be interpreted simply as evidence of teacher neglect; they may also reflect weaknesses in the professional and institutional conditions required for effective technology integration.

4. Methodology

The study adopted a descriptive survey design to investigate awareness and utilisation of online chemistry instructional resources among 234 secondary school chemistry teachers in Kwara State, Nigeria. Because the target population comprised 234 identified chemistry teachers, a census approach was used rather than probability sampling. This enabled the study to cover the entire accessible population and avoided sampling error within that defined population. Data were collected using the Online Chemistry Instructional Resources Questionnaire (OCIRQ), described in the study as an adapted instrument based on a validated inventory. The questionnaire covered

Vol. 2, No. 1, 2026 - Kwararafa University Journal of Multidisciplinary Research and Innovation
Pub. Link: https://aa.unij.co.uk/index.php/kujmri/issue/view/6 - E- ISSN: 3156-5492 | P- ISSN: 3156-5514

46 online chemistry resources and assessed awareness on a three-point scale (3 = High, 2 = Moderate, 1 = None) and utilisation on a three-point scale (3 = Frequent, 2 = Rare, 1 = Not Used). The instrument was subjected to expert validation and yielded a Cronbach's alpha coefficient of 0.71.

Before participation, informed consent was sought and obtained from all participants. Participation was voluntary, and data were collected over four weeks. Frequencies, percentages, and mean scores were used to summarise awareness and utilisation. A mean score of 2.0 was specified as the benchmark for adequate awareness and utilisation. For the third research question, chi-square tests of independence were used to examine whether the distribution of categorical responses differed significantly across gender, teaching-experience, and professional-qualification groups. The hypotheses were tested at the 0.05 level of significance. Because the design was descriptive and cross-sectional, the analyses establish patterns of association rather than causal effects; accordingly, terms such as 'influence' are not interpreted causally.

5. Results

5.1 Demographic Characteristics of Participants

Table 1: Demographic Characteristics of Participants (N = 234)

Variable	Category	Frequency	Percentage (%)
Gender	Male	126	53.8
	Female	108	46.2
Professional Qualification	Qualified (B.Ed., B.Sc. Ed., B.Sc. + PGDE)	197	84.2
	Unqualified	37	15.8
Teaching Experience	Experienced (>10 years)	49	20.9
	Moderately Experienced (5-10 years)	102	43.6
	Less Experienced (<5 years)	83	35.5

As shown in Table 1, the participants were relatively balanced by gender, although male teachers constituted a slightly larger proportion. The sample was predominantly composed of professionally qualified teachers, while teachers with 5–10 years of experience constituted the largest experience group.

Vol. 2, No. 1, 2026 - Kwararafa University Journal of Multidisciplinary Research and Innovation
Pub. Link: https://aa.unij.co.uk/index.php/kujmri/issue/view/6 - E- ISSN: 3156-5492 | P- ISSN: 3156-5514

5.2 Research Question 1: Level of Awareness of Online Chemistry Instructional Resources

Table 2: Summary of Awareness Levels of Online Chemistry Instructional Resources

Awareness classification	No. of resources	Highest example	Mean score(s)
High awareness	1	chemistryguide.org (49.1% high awareness)	2.46
Adequate awareness (≥2.0)	15	Chemicalelements.com (2.29)	2.00–2.29
Below benchmark (<2.0)	31	Chemieunterricht.de (1.09)	1.09–1.99

Note. Mean scores are based on a three-point scale: 3 = High, 2 = Moderate, 1 = None. A mean score of ≥2.0 was used as the benchmark for adequate awareness.

Table 2 shows that awareness was unevenly distributed across the 46 resources. Only one resource, chemistryguide.org, recorded a mean score in the high-awareness category (M = 2.46), while a further 14 resources recorded mean scores from 2.00 to 2.29. Thus, 15 of the 46 resources (32.6%) met or exceeded the predefined benchmark for adequate awareness, whereas 31 resources fell below it. The results indicate that teachers' awareness was concentrated in a relatively small subset of the resources examined rather than being broadly distributed across the online chemistry resource landscape.

5.3 Research Question 2: Level of Utilisation of Online Chemistry Instructional Resources

Table 3: Summary of Utilisation Levels of Online Chemistry Instructional Resources

Utilisation classification	No. of resources	Highest example	Mean score(s)
Adequate utilisation (≥2.0)	12	chemistryguide.org (M = 2.32)	2.00–2.32
Below benchmark (<2.0)	34	Chemieunterricht.de (M = 1.09)	1.09–1.99
Frequently used by a majority	0	Highest frequency of use: chemistryguide.org (39.7%)	

Note. Mean scores are based on a three-point scale: 3 = Frequent, 2 = Rare, 1 = Not Used. A mean score of ≥2.0 was used as the benchmark for adequate utilisation.

Table 3 shows that utilisation of online chemistry instructional resources was generally limited. Of the 46 resources examined, 12 (26.1%) met or exceeded the predefined benchmark of 2.0 for adequate utilisation, whereas 34 (73.9%) fell below the benchmark. None of the resources was

Vol. 2, No. 1, 2026 - Kwararafa University Journal of Multidisciplinary Research and Innovation
Pub. Link: https://aa.unij.co.uk/index.php/kujmri/issue/view/6 - E- ISSN: 3156-5492 | P- ISSN: 3156-5514

frequently used by a majority of the teachers. Chemistryguide.org recorded the highest utilisation mean (M = 2.32) and the highest proportion of frequent use (39.7%). The results therefore indicate that, although some online chemistry instructional resources had reached a relatively adequate level of utilisation, regular classroom use remained limited across the resource set. The pattern therefore suggests that even where awareness was relatively higher, regular classroom use remained limited.

5.4 Research Question 3: Associations between Demographic Characteristics and Awareness and Utilisation

Table 4: Chi-Square Test Results: Associations between Demographic Characteristics and Awareness and Utilisation

Demographic Variable	Outcome	χ^2	**df**	p-value	Inference
Gender	Awareness	4.341	2	.114	Not significant; H_0 not rejected
	Utilisation	0.139	2	.933	Not significant; H_0 not rejected
Teaching Experience	Awareness	1.196	4	.879	Not significant; H_0 not rejected
	Utilisation	5.968	4	.202	Not significant; H_0 not rejected
Professional Qualification	Awareness	4.194	2	.123	Not significant; H_0 not rejected
	Utilisation	1.479	2	.477	Not significant; H_0 not rejected

Note. The chi-square tests assess whether the distribution of categorical awareness and utilisation responses differed significantly across demographic groups. Statistical significance was evaluated at $\alpha = .05$.

Table 4 indicates that none of the six tests reached statistical significance at $\alpha = .05$. Gender was not significantly associated with awareness, $\chi^2(2) = 4.341$, $p = .114$, or utilisation, $\chi^2(2) = 0.139$, $p = .933$. Teaching experience was not significantly associated with awareness, $\chi^2(4) = 1.196$, $p = .879$, or utilisation, $\chi^2(4) = 5.968$, $p = .202$. Similarly, professional qualification was not significantly associated with awareness, $\chi^2(2) = 4.194$, $p = .123$, or utilisation, $\chi^2(2) = 1.479$, $p = .477$. The six null hypotheses were therefore not rejected. These results indicate that the distribution of awareness and utilisation responses did not differ significantly across the demographic categories examined; they do not, however, demonstrate that the demographic variables have no effect whatsoever.

Vol. 2, No. 1, 2026 - Kwararafa University Journal of Multidisciplinary Research and Innovation
Pub. Link: https://aa.unij.co.uk/index.php/kujmri/issue/view/6 - E- ISSN: 3156-5492 | P- ISSN: 3156-5514

6. Discussion of Findings

The first research question examined teachers' awareness of online chemistry instructional resources. The findings indicate that awareness was concentrated in a small proportion of the resources examined. Only one resource attained the high-awareness category, while 15 of the 46 resources met or exceeded the study's benchmark for adequate awareness. This suggests a subject-specific awareness gap within the study population. The finding is consistent with Ugwu and Ohimekpen (2015), who reported limited awareness and use of e-learning resources among secondary-school teachers in Yobe State. However, because the present study is confined to Kwara State and uses a subject-specific resource inventory, the result should be interpreted as evidence about this local context rather than as proof of a national pattern.

The second research question addressed utilisation and revealed a narrower pattern of engagement. Although 15 resources met the awareness benchmark, only 12 met the utilisation benchmark, and no resource was frequently used by a majority of teachers. The overall utilisation means reported in Appendix C ranged from 1.74 to 1.78 across the demographic groups, all below the study-defined benchmark of 2.0. This divergence between awareness and utilisation indicates that awareness of a resource does not necessarily translate into sustained instructional use. The pattern is consistent with literature showing that technology integration depends on enabling conditions and teacher-level knowledge (Ifinedo et al., 2020; Menkiti & Menkiti, 2013), but the present survey did not directly measure these explanatory factors.

The third research question examined whether awareness and utilisation differed significantly across gender, teaching experience, and professional qualification. None of the six chi-square tests was statistically significant (all $p > .05$). The finding is compatible with evidence showing that demographic differences in technology-related practices are not always consistent across contexts (Egede, 2021; Fakomogbon *et al*., 2015; Gorder, 2008). It should not, however, be interpreted as evidence that demographic characteristics are universally irrelevant. Rather, within this sample and the categorical measures employed, there was insufficient evidence to conclude that the distributions of awareness or utilisation differed across the demographic groups examined.

The findings therefore point to an awareness–practice gap: teachers may know about some online chemistry instructional resources without incorporating them regularly into classroom practice. This pattern is consistent with structural, institutional, and professional conditions identified in the literature, although these conditions were not directly measured in the present survey. The observed utilisation gap should therefore be interpreted as an empirical pattern requiring further investigation rather than as evidence that any particular contextual factor caused limited use.

6.4 Implications

The findings indicate that limited adoption of online chemistry instructional resources is not significantly differentiated by the demographic characteristics examined. However, the cross-sectional design does not establish that systemic conditions caused the observed pattern. The principal implication is therefore the need for interventions that address the enabling conditions for technology integration across the teacher workforce. These include reliable infrastructure, practical TPACK-oriented professional development, access to curated subject-specific resources, and institutional support for sustained classroom use.

Vol. 2, No. 1, 2026 - Kwararafa University Journal of Multidisciplinary Research and Innovation
Pub. Link: https://aa.unij.co.uk/index.php/kujmri/issue/view/6 - E- ISSN: 3156-5492 | P- ISSN: 3156-5514

7. Conclusion

This study found that awareness and utilisation of online chemistry instructional resources among secondary school chemistry teachers in Kwara State were limited. Of the 46 resources examined, 15 met or exceeded the benchmark for adequate awareness and 12 met or exceeded the benchmark for adequate utilisation; no resource was frequently used by a majority of teachers. Chi-square tests found no statistically significant associations between gender, teaching experience, or professional qualification and either awareness or utilisation. The findings therefore suggest that the observed limitations are not significantly differentiated across the demographic groups examined. Given the descriptive and cross-sectional nature of the study, the results should be interpreted as evidence of patterns and associations rather than causal effects. Addressing the identified awareness-to-practice gap requires coordinated attention to infrastructure, subject-specific digital pedagogy, professional development, resource curation, and institutional support.

7.2 Recommendations

To address the constraints identified and the gaps suggested by the findings, four strategic priorities are proposed:

1. Infrastructure development: Government and school authorities should strengthen the reliability of electricity supply, internet connectivity, and access to appropriate digital hardware, while monitoring whether such improvements increase actual classroom utilisation.
2. Teacher capacity building: Pre-service and in-service professional development should incorporate practical, chemistry-specific TPACK competencies, with emphasis on selecting, adapting, and integrating online resources into curriculum-aligned lessons.
3. Resource provision and access: Educational agencies and professional associations should curate locally relevant repositories of vetted online chemistry resources, organised by curriculum topic and accompanied by concise guidance on pedagogical use.
4. Policy and accountability: Education authorities should establish realistic, measurable indicators for technology integration in chemistry instruction and provide monitoring, mentoring, and implementation support rather than relying solely on resource provision.

7.3 Limitations

The findings should be interpreted within the scope of the study. The cross-sectional design describes patterns of awareness and utilisation and their associations with selected demographic characteristics but does not permit causal inferences. The use of self-reported data may also introduce recall or social-desirability bias. Although the census approach covered the identified population of 234 chemistry teachers in Kwara State, generalisation to other contexts should be made with caution. Finally, the study did not examine contextual factors such as infrastructure, institutional support, or teachers' TPACK competence; these may be considered in future research.

Vol. 2, No. 1, 2026 - Kwararafa University Journal of Multidisciplinary Research and Innovation
Pub. Link: https://aa.unij.co.uk/index.php/kujmri/issue/view/6 - E- ISSN: 3156-5492 | P- ISSN: 3156-5514

References

Dori, Y. J., & Barak, M. (2001). Virtual and physical molecular modelling: Fostering model perception and spatial understanding. *Educational Technology & Society, 4*(1), 61–74.

Egede, B. A. J. (2021). Student teachers' readiness to use information and communication technology (ICT) to teach: Exploring the influence of gender. *Academia Letters*, Article 491. https://doi.org/10.20935/AL491

Fakomogbon, M. A., Olanrewaju, O. S., & Soetan, A. K. (2015). Lecturers' awareness and utilisation of instructional media in the state-owned colleges of education, South-West Nigeria. *Malaysian Online Journal of Educational Technology, 3*(2), 13–19.

Gorder, L. M. (2008). A study of teacher perceptions of instructional technology integration in the classroom. *The Delta Pi Epsilon Journal, 50*(2), 63–76.

Hwang, G. J., Wang, S. Y., & Lai, C. L. (2021). Effects of a social regulation-based online learning framework on students' learning achievements and behaviours in mathematics. *Computers & Education, 160*, 104031. https://doi.org/10.1016/j.compedu.2020.104031

Ifinedo, E., Rikala, J., & Hämäläinen, T. (2020). Factors affecting Nigerian teacher educators' technology integration: Considering characteristics, knowledge constructs, ICT practices and beliefs. *Computers & Education, 146*, 103760. https://doi.org/10.1016/j.compedu.2019.103760

Jang, S.-J., & Chen, K.-C. (2010). From PCK to TPACK: Developing a transformative model for pre-service science teachers. *Journal of Science Education and Technology, 19*(6), 553–564. https://doi.org/10.1007/s10956-010-9222-y

Jonassen, D. H., Howland, J., Marra, R. M., & Crismond, D. (2008). *Meaningful learning with technology* (3rd ed.). Pearson.

Menkiti, N. U., & Menkiti, U. B. (2013). Assessment and prospective application of information and communication technology usage among secondary school teachers in Enugu Urban, Nigeria. *Journal of Education, Society and Behavioural Science, 4*(3), 336–349. https://doi.org/10.9734/BJESBS/2014/5841

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x

Ololube, N. P. (2006). The impact of professional and non-professional teachers' ICT competencies in secondary schools in Nigeria. *Journal of Information Technology Impact, 6*(2), 101–118.

Omiko, A. (2016). Investigating the availability and the extent of use of instructional materials by secondary school chemistry teachers in Nigeria. *International Journal of Education, Learning and Development, 4*(3), 1–11.

Vol. 2, No. 1, 2026 - Kwararafa University Journal of Multidisciplinary Research and Innovation
Pub. Link: https://aa.unij.co.uk/index.php/kujmri/issue/view/6 - *E*- ISSN: 3156-5492 | *P*- ISSN: 3156-5514

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1–23. https://doi.org/10.17763/haer.57.1.j463w79r56455411

Suprapto, N., Nandyansah, W., & Mubarok, H. (2021). The implementation of virtual laboratory in science education: A systematic review. *Journal of Technology and Science Education, 11*(1), 79–94. https://doi.org/10.3926/jotse.1143

Tondeur, J., van Braak, J., Ertmer, P. A., & Ottenbreit-Leftwich, A. (2017). Understanding the relationship between teachers' pedagogical beliefs and technology use in education: A systematic review of qualitative evidence. *Educational Technology Research and Development, 65*(3), 555–575. https://doi.org/10.1007/s11423-016-9481-2

Ugwu, D. A., & Ohimekpen, B. A. (2015). An assessment of awareness and use of e-learning resources by secondary school teachers in the North Eastern State of Yobe, Nigeria. *International Journal of Management and Applied Science, 1*(10), 117–122.