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In-Service Teachers' Knowledge of Data Literacy and Civic Engagement in the Digital Age: Implications for Educational Practice and Environmental Awareness

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Abstract

This study investigated in-service secondary school teachers' knowledge and practices regarding data literacy and civic engagement in the digital age, with emphasis on their implications for educational practice and environmental awareness. Grounded in Digital Citizenship Theory and Constructivist Learning Theory, the study employed a descriptive survey research design to capture teachers' current knowledge, attitudes, and classroom applications without manipulation of variables. The population consisted of 1,746 in-service teachers across public secondary schools in the Nsukka Education Zone, Enugu State, Nigeria. Using Taro Yamane's formula and a multistage sampling technique, a total of 326 teachers were selected to participate in the study. Data were collected using a structured instrument titled In-Service Teachers' Knowledge of Data Literacy and Civic Engagement Questionnaire (ITKDLCEQ), adapted from established tools on data literacy, digital citizenship, and civic responsibility. The instrument was validated by experts, followed by pilot testing and the reliability analysis using Cronbach's alpha yielded a coefficient of 0.81, indicating good internal consistency. Findings revealed that while teachers demonstrated moderate knowledge of data literacy and civic engagement, their classroom practices reflected limited integration of these competencies. Challenges such as insufficient digital resources, lack of training, and curriculum constraints were identified as key barriers. The results underscore the urgent need for targeted professional development, improved infrastructural support, and curriculum reforms that incorporate digital citizenship, environmental responsibility, and data-informed instructional strategies. Ultimately, the study highlights the importance of equipping educators with the competencies necessary to foster environmentally conscious and civically engaged learners in a digitally connected society.

Keywords: *Data literacy, civic engagement, environmental education, digital citizenship, teaching practice, in-service teachers*

INTRODUCTION

The 21st century has witnessed a surge in digital technologies that have reshaped how individuals access information, participate in civic life, and engage with environmental and social issues (Egara et al., 2025; Okafor et al., 2023a, 2023b). In this evolving landscape, data literacy and civic engagement have emerged as essential competencies for both educators and learners (Donate-Beby et al., 2025). Data literacy, the ability to access, interpret, evaluate, and use data effectively, is foundational for making informed decisions in today's data-driven world (Wolff et al., 2016). Similarly, civic engagement, especially in the digital realm, empowers individuals to actively participate in societal and environmental discourse, fostering democratic values and sustainable practices (Nchaga, 2025).

Teachers play a pivotal role in equipping students with these competencies. In-service teachers, in particular, must possess strong data literacy and a keen understanding of civic engagement to guide students in navigating complex digital environments (Schramm-Possinger & Harris, 2021). This is especially critical in an era marked

by the proliferation of misinformation, climate change debates, and pressing socio-environmental challenges that demand informed citizen participation.

Despite the growing importance of these concepts, limited empirical evidence exists regarding in-service teachers' knowledge of data literacy and their preparedness to foster civic engagement among learners. In many educational systems, particularly in developing countries, teacher training programmes have not kept pace with digital transformation (Mhlanga, 2024), often leaving teachers underprepared to incorporate these skills into their instructional practices. Moreover, there is a lack of understanding about how well teachers integrate digital civic tools or environmental data into their lessons to promote awareness and action among students (Chansa et al, 2024).

The implication of this gap is significant: if teachers lack adequate knowledge of data literacy and civic engagement, the goal of developing environmentally aware, socially responsible, and digitally competent students may remain unfulfilled. Therefore, understanding in-service teachers' current knowledge of these key areas is crucial for informing professional development programmes, curricular integration, and broader educational reforms aimed at sustainability and responsible digital citizenship.

Theoretical Framework

This study is grounded in two interrelated theoretical perspectives: Digital Citizenship Theory and Constructivist Learning Theory. Digital Citizenship Theory, as proposed by Ribble (2012), centres on the norms of appropriate and responsible behaviour in digital environments. It includes dimensions such as digital communication, digital literacy, digital rights and responsibilities, and digital participation. This theory aligns with the civic engagement component of the study, as it underscores the need for educators to not only use digital tools but also teach students how to use them ethically and for civic purposes, including environmental activism, social justice, and participation in democratic processes. In the context of this study, in-service teachers are viewed as critical agents in modelling and facilitating digital citizenship. Their knowledge of how digital tools can be used for civic engagement, such as participating in online petitions, contributing to environmental discussions, or interpreting climate-related data, reflects their preparedness to promote socially responsible digital behaviour.

Constructivist Learning Theory (Vygotsky, 1978; Piaget, 1950) emphasizes that learning is an active, contextualized process of constructing knowledge through experience and reflection. In terms of data literacy, this theory supports the idea that learners (including teachers) construct understanding when they engage with real-world data, critically analyse it, and draw conclusions through guided instruction. When applied to the classroom, constructivism highlights the importance of hands-on, inquiry-based learning. Teachers with strong data literacy skills are better equipped to design learning experiences where students explore environmental data sets, analyse patterns (e.g., pollution or deforestation trends), and engage in problem-solving, thus linking theoretical knowledge with civic action. Together, these frameworks provide a lens through which to evaluate in-service teachers' preparedness in using digital tools for fostering civic responsibility and promoting data-driven environmental education.

LITERATURE REVIEW

A growing body of literature emphasizes the role of data literacy in contemporary education. According to Mandinach and Gummer (2016), data literacy involves understanding how to collect, interpret, and use data to inform teaching and decision-making. This competence is seen as essential to evidence-based instructional practices. However, teachers often lack formal preparation in this area. For example, Jimerson and Wayman (2015) found that while many educators value data use, professional learning opportunities to support data-informed decision-making are often inadequate. Similarly, Datnow and Hubbard (2015) reported that teachers tend to use data in superficial or compliance-driven ways, constrained by institutional norms and the lack of deeper data literacy training.

Although most studies on data literacy focus on improving pedagogical practices, fewer have examined how teachers use data to engage students in real-world environmental or civic issues. Ardoin et al. (2022) noted that when educators incorporate authentic data sets into instruction, students become more inclined toward inquiry and civic action, particularly on environmental matters. In a related study, Deahl (2014) suggested

that data literacy empowers both teachers and learners to analyse environmental trends, enabling informed decision-making and awareness.

Civic engagement in the digital age has also attracted scholarly attention. Rheingold (2012) highlighted how digital tools and social media platforms offer new avenues for civic expression, activism, and participatory culture. Building on this, Westheimer and Kahne (2004) argued that democratic education must go beyond civic knowledge to include civic participation, advocacy, and action. These skills, now digitally mediated, are essential in cultivating responsible, engaged citizens. However, gaps persist in how these ideals are implemented in classrooms. Choi et al. (2017) found that many teachers are underprepared to integrate digital citizenship effectively, primarily due to inadequate training and competing curriculum demands. Similarly, Kahne, Hodgin, and Eidman-Aadahl (2016) observed that civic education is often marginalized in classroom practice, even though its importance in the digital age is widely acknowledged.

In the realm of environmental education, the integration of civic engagement and data literacy is gaining traction. Evans et al. (2020) and Davis et al. (2020) emphasized that civic engagement can be a powerful tool for environmental awareness when students are encouraged to take action on local or global issues. Likewise, Freeman et al. (2019) underscored the importance of equipping learners with the knowledge and tools to participate meaningfully in shaping sustainable environments. However, while these studies affirm the value of integrated approaches, empirical work focusing specifically on in-service teachers' roles in this regard remains limited. This limitation is particularly pronounced in low- and middle-income countries. In the Nigerian context, Guerrero Elecalde et al. (2024) reported that many teachers lack training in the use of digital tools for civic or environmental education, despite curriculum policies that emphasize these competencies. Similarly, Matusevych (2018) identified systemic challenges, such as overloaded curricula, insufficient infrastructure, and inadequate professional development, as significant barriers to civic and environmental education globally.

Although the intersections of data literacy, civic engagement, and environmental awareness have been well-theorized, there is a notable gap in empirical research that examines how in-service teachers, particularly in developing contexts, engage with and apply these concepts in practice. Much of the existing research focuses on pre-service teachers or general digital literacy, leaving a limited understanding of how current educators navigate these complex yet essential educational demands. This study addresses that gap by examining in-service teachers' knowledge, challenges, and perceived implications of integrating data literacy and civic engagement within the secondary school context in Nigeria. Therefore, the study aims to (i) to assess in-service teachers' knowledge of data literacy and its relevance to environmental education (ii) to evaluate in-service teachers' understanding of civic engagement in the digital age (iii) to identify the challenges and limitations faced by teachers in integrating data literacy and civic engagement in their teaching, and (iv) to determine the implications of teachers' knowledge (or lack thereof) for educational practices promoting environmental awareness and civic responsibility.

Research Questions

The following research questions were formulated to guide the study.

1. What is the level of knowledge in-service teachers possess regarding data literacy in the context of educational practice?
2. How well do in-service teachers understand and integrate civic engagement in the digital age into their instructional practices?
3. What challenges do in-service teachers face in applying data literacy and civic engagement concepts in the classroom?
4. What are the implications of in-service teachers' knowledge of data literacy and civic engagement for environmental education and teaching practice?

METHODS

Research Design

This study employed a descriptive survey research design, which is appropriate for investigating current practices, knowledge, and attitudes of a target population without manipulating any variables. As noted by Creswell (2014), descriptive survey design is ideal for studies that aim to describe characteristics or opinions

of a group based on data collected through standardized instruments. This design enabled the researchers to explore in-service secondary school teachers' knowledge of data literacy and civic engagement in the digital age, particularly its implications for educational practice, within a natural school setting.

Population and Sample

The population of this study comprised 1,746 in-service teachers currently teaching in public secondary schools in Nsukka Education Zone, Enugu State, Nigeria. This population figure was obtained from the Post Primary Schools Management Board (2024). The Nsukka Education Zone includes three Local Government Areas: Nsukka, Igbo-Etiti, and Uzo-Uwani. The in-service teachers in this study included a diverse range of educators teaching various subjects (e.g., mathematics, English, social studies, basic science and civic education) across junior and senior secondary school levels. Teachers varied in their years of teaching experience, educational qualifications, and exposure to digital tools for instruction. Using Taro Yamane's (1967) method for sample size determination, a total of 326 in-service teachers were selected. A multistage sampling technique was adopted. First, five secondary schools were randomly selected from each of the three LGAs, making a total of 15 schools. Then, proportionate stratified random sampling was used to select teachers from each school based on staff size, ensuring representation from all three LGAs and various subject disciplines.

Instrumentation

The instrument used for data collection was a structured questionnaire titled In-Service Teachers' Knowledge of Data Literacy and Civic Engagement Questionnaire (ITKDLCEQ). The questionnaire was adapted from validated instruments developed by Mandinach and Gummer (2016), Choi et al. (2017), and Westheimer and Kahne (2004), which assess data literacy, digital citizenship, and civic responsibility, respectively.

The ITKDLCEQ consisted of three sections. Section A gathered demographic information such as gender, years of teaching experience, subject area, and school location. Section B comprised 12 items assessing teachers' knowledge and application of data literacy in their professional practices, including data use for instructional planning, assessment, and feedback. Section C contained 12 items measuring teachers' understanding and promotion of civic engagement in the digital age, with a focus on environmental responsibility, digital participation, and social consciousness in education. Items in Sections B and C were structured on a 4-point Likert-type scale ranging from Strongly Disagree (1) to Strongly Agree (4).

The instrument was subjected to face and content validation by three experts in Educational Technology, Measurement and Evaluation, and Curriculum Studies. Their feedback ensured that the items were clear, contextually appropriate, and aligned with the research objectives. A pilot test was conducted using a sample of 48 in-service teachers from schools outside the Nsukka Education Zone. Data from the pilot study were analysed to determine the instrument's reliability using Cronbach's alpha, which yielded a coefficient of 0.81, indicating good internal consistency (George & Mallery, 2003).

Method of Data Collection

The data collection process took place during the second term of the 2024/2025 academic year. The researchers personally visited the selected schools to administer the questionnaires. Teachers were briefed on the purpose of the study and assured of confidentiality and voluntary participation. Copies of the questionnaire were distributed and retrieved on the spot to maximize response rates. The researchers' active involvement in the process facilitated smooth coordination and clarity, resulting in a 100% retrieval rate of the administered instruments.

Data Analysis

Data collected were analysed using the Statistical Package for the Social Sciences (SPSS), version 28. Descriptive statistics, specifically mean and standard deviation, were used to answer the research questions. To interpret the mean scores from the Likert-type items, a standardized scale was adopted across the different constructs assessed. For teachers' knowledge of data literacy and integration of civic engagement, mean scores were interpreted as follows: 3.50–4.00 = Very High Knowledge/Integration (VHK/VHI), 2.50–3.49 = High Knowledge/Integration (HK/HI), 1.50–2.49 = Low Knowledge/Integration (LK/LI), and 1.00–1.49 = Very Low Knowledge/Integration (VLK/VLI). For challenges in applying data literacy and civic engagement, the same range was applied but interpreted as: 3.50–4.00 = Very High Challenge (VHC), 2.50–3.49 = High Challenge (HC), 1.50–2.49 = Low Challenge (LC), and 1.00–1.49 = Very Low Challenge (VLC). For

implications for environmental education and teaching practice, scores were also categorized using: 3.50–4.00 = Very High Implication (VHI), 2.50–3.49 = High Implication (HI), 1.50–2.49 = Low Implication (LI), and 1.00–1.49 = Very Low Implication (VLI). These benchmarks facilitated consistent interpretation of the levels of knowledge, integration, challenges, and perceived implications across the study variables.

RESULTS

This section presents the results of the study in line with the four research questions posed.

Research Question 1

What is the level of knowledge in-service teachers possess regarding data literacy in the context of educational practice?

Table 1

Mean and Standard Deviation of In-Service Teachers' Knowledge of Data Literacy in Educational Practice

S/N	Items	M	SD	Discission
1	I understand how to collect and analyse student performance data to guide instruction.	3.04	1.06	HK
2	I regularly use assessment data to improve my teaching strategies.	2.84	1.11	HK
3	I can effectively interpret charts, tables, and graphs related to student outcomes.	2.34	.86	LK
4	I know how to use data to differentiate instruction based on student needs.	2.21	.92	LK
5	I am confident in using school-based digital tools to collect and analyse data.	2.56	1.19	HK
6	I have received adequate training in the use of data in teaching and learning.	2.33	1.13	LK
	Grand Mean	**2.55**	**1.05**	**HK**

As shown in Table 1, the overall grand mean score for the six items was 2.55 (SD = 1.05), indicating a high level of knowledge of data literacy among the respondents. Specifically, respondents reported high knowledge in understanding how to analyse student performance data (M = 3.04, SD = 1.06), using assessment data to improve instruction (M = 2.84, SD = 1.11), and utilizing school-based digital tools (M = 2.56, SD = 1.19). However, they demonstrated lower levels of knowledge in key areas such as interpreting charts and graphs (M = 2.34, SD = 0.86), using data to differentiate instruction (M = 2.21, SD = 0.92), and receiving adequate training on data usage (M = 2.33, SD = 1.13). These findings suggest that while in-service teachers possess moderate to high awareness of basic data literacy principles, specific gaps exist in technical competencies and training access, highlighting areas where further professional development is necessary.

Research Question 2

How well do in-service teachers understand and integrate civic engagement in the digital age into their instructional practices?

Table 2 Mean and Standard Deviation of In-Service Teachers' Integration of Civic Engagement in the Digital Age

S/N	Items	M	SD	Discission
7	I teach students about their rights and responsibilities in digital spaces.	2.62	.10	HI
8	I integrate digital citizenship topics into classroom discussions.	2.40	.82	LI
9	I encourage students to use social media positively for civic and environmental causes.	2.55	1.06	HI
10	I understand how to guide students on ethical online behaviour.	2.39	1.11	LI
11	I promote classroom activities that address real-life community or environmental issues.	2.71	1.14	HI

12	I believe civic engagement should be part of digital literacy education.	2.37	.92	LI
Grand Mean		**2.51**	**.86**	**HI**

As shown in Table 2, the grand mean score for in-service teachers' integration of civic engagement in the digital age was 2.51 (SD = 0.86), indicating an overall high level of integration. Notably, respondents reported relatively strong agreement with items related to teaching about students' rights in digital spaces (M = 2.62, SD = 0.10), promoting community-based classroom activities (M = 2.71, SD = 1.14), and encouraging civic use of social media (M = 2.55, SD = 1.06). However, lower mean scores were recorded for items regarding the integration of digital citizenship topics (M = 2.40, SD = 0.82), understanding ethical online behaviour (M = 2.39, SD = 1.11), and believing in the importance of civic engagement in digital literacy education (M = 2.37, SD = 0.92). These findings suggest that while in-service teachers generally recognize and apply some aspects of civic engagement in digital contexts, their practices may not be consistently embedded across all instructional domains. This calls for more structured professional learning experiences to enhance teachers' confidence and competence in promoting civic responsibility in the digital age.

Research Question 3

What challenges do in-service teachers face in applying data literacy and civic engagement concepts in the classroom?

Table 3 Mean and Standard Deviation of In-Service Teachers' Perceived Challenges in Applying Data Literacy and Civic Engagement

S/N	Items	M	SD	Discission
13	I find it difficult to apply data literacy concepts due to lack of digital resources.	2.64	1.04	HC
14	I face challenges in engaging students in civic or environmental discussions.	2.44	1.02	LC
15	There is insufficient training for teachers on civic engagement in the digital age.	2.87	.97	HC
16	Curriculum pressure limits my ability to teach data and civic-related skills.	2.66	1.04	HC
17	My school lacks policies that support civic education in the digital era.	2.75	1.08	HC
18	I struggle to align civic engagement with subject content.	2.73	1.07	HC
	Grand Mean	**2.68**	**1.04**	**HC**

As presented in Table 3, the grand mean of 2.68 (SD = 1.04) indicates that in-service teachers perceive a high level of challenges in applying data literacy and civic engagement within their classrooms. The highest-rated item was the lack of adequate training on civic engagement in the digital age (M = 2.87, SD = 0.97), followed closely by absence of supportive school policies (M = 2.75, SD = 1.08) and difficulty aligning civic topics with subject content (M = 2.73, SD = 1.07). Although the challenge of engaging students in civic or environmental discourse received a relatively lower rating (M = 2.44, SD = 1.02), it still suggests the presence of moderate difficulty in this area. These results underscore the need for targeted professional development, institutional support, and curriculum flexibility to enable teachers to overcome practical barriers and effectively implement data literacy and civic engagement themes.

Research Question 4

What are the implications of in-service teachers' knowledge of data literacy and civic engagement for environmental education and teaching practice?

Table 4 Mean and Standard Deviation of In-Service Teachers' Perceived Implications of Data Literacy and Civic Engagement for Environmental Education and Teaching Practice

S/N	Items	M	SD	Discission
19	My understanding of data literacy enhances how I teach environmental concepts.	2.19	.91	LI

20	I use civic education to foster environmental responsibility in my students.	3.08	1.00	HI
21	I design lessons that encourage students to use data to solve real-world environmental problems.	2.29	.87	LI
22	I help students understand how civic actions can address local and global environmental issues.	2.56	.90	HI
23	I feel empowered to lead community-based environmental projects with my students.	2.55	1.06	HI
24	Data literacy and civic education are important for effective 21st-century teaching practice.	2.73	1.03	HI
	Grand Mean	**2.57**	**0.96**	**HI**

As shown in Table 4, the grand mean score of 2.57 (SD = 0.96) indicates a high level of perceived implication of data literacy and civic engagement for environmental education and teaching practice among in-service teachers. Among the items, the belief that civic education fosters environmental responsibility (M = 3.08, SD = 1.00) received the highest mean score, followed by the perception that these competencies are important for 21st-century teaching (M = 2.73, SD = 1.03). However, lower mean scores were observed in areas related to the direct application of data literacy in teaching environmental concepts (M = 2.19, SD = 0.91) and lesson planning that incorporates environmental data (M = 2.29, SD = 0.87), suggesting that while teachers conceptually value these connections, practical integration may still be underdeveloped.

DISCUSSION

This study investigated in-service teachers' knowledge and application of data literacy and civic engagement within educational contexts, the challenges they face, and the implications for environmental education and 21st-century teaching practices. The findings are discussed in alignment with relevant empirical literature and the guiding theoretical frameworks: Digital Citizenship Theory and Constructivist Learning Theory.

The analysis revealed that in-service teachers possessed a moderate level of knowledge of data literacy, with a grand mean of 2.55. Teachers showed some capacity in using student data to inform instruction and in utilizing digital tools for data collection and analysis. However, limitations were observed in interpreting data visualizations and receiving adequate training on data-driven practices. These findings are consistent with Mandinach and Gummer (2016), who argued that while teachers recognize the importance of data in informing pedagogy, many still lack formal training and support systems to build robust data literacy skills. Similarly, Datnow and Hubbard (2015) found that teachers often use data in superficial ways due to institutional constraints and inadequate professional development. Aligned with Constructivist Learning Theory, these findings suggest that in-service teachers may not be receiving sufficient opportunities for hands-on, experiential engagement with real-world educational data. Constructivism emphasizes knowledge construction through active inquiry, and without deliberate practice and scaffolding, teachers may struggle to cultivate deep data literacy. Teachers' limited ability to interpret and apply data also implies a gap in their readiness to design student-centred, data-rich learning environments.

With a grand mean of 2.51, the findings suggest that teachers moderately integrate civic engagement concepts into classroom practices. They acknowledged the importance of digital citizenship, taught ethical online behaviour, and promoted civic discussions, though the frequency and depth of such integration varied. This finding supports Choi et al. (2017), who noted that while teachers increasingly value civic engagement in digital education, actual integration remains limited due to competing curriculum demands and a lack of structured support. Additionally, Kahne, Hodgin, and Eidman-Aadahl (2016) reported that civic education is often marginalized, particularly when digital tools are involved, despite its growing relevance in fostering responsible and engaged citizens. According to Digital Citizenship Theory (Ribble, 2012), effective integration of civic engagement in digital contexts requires teachers to be role models of responsible online behaviour and facilitators of digital participation. The moderate integration reported in this study indicates partial alignment with the theory's dimensions, particularly in fostering students' online rights, responsibilities, and ethical behaviours. Furthermore, civic engagement in teaching connects to constructivist ideals, encouraging learners to participate in real-life social and environmental issues through dialogue,

collaboration, and problem-solving. While some teachers promoted civic discussions, the overall findings suggest a need for deeper constructivist practices that position students as active participants in digital civic life.

Teachers reported facing significant challenges in applying data literacy and civic engagement concepts in their classrooms, with a grand mean of 2.68. The major constraints included lack of digital resources, insufficient training, curriculum pressure, and absence of institutional policies supporting civic engagement. This finding echoes the results of Jimerson and Wayman (2015) and Matusevych (2018), who documented similar systemic challenges affecting data-driven instruction and civic education. Teachers often cite overloaded curricula and lack of infrastructure as barriers to innovation and integration of 21st-century skills. The challenges reported also align with Constructivist Learning Theory, which asserts that without enabling conditions, such as access to technology, training, and time, teachers cannot effectively engage in the reflective, inquiry-based teaching required for developing data-literate and civically engaged learners. Similarly, Digital Citizenship Theory implies that institutional support is vital for nurturing responsible online participation and civic activism, both of which were hampered by systemic limitations in the study context.

The findings from this section revealed a moderate perception of the implications of data literacy and civic engagement for environmental education and teaching practice, with a grand mean of 2.57. While teachers believed that civic education fosters environmental responsibility and felt empowered to involve students in environmental projects, fewer teachers reported using data to teach environmental concepts or support real-world problem-solving. These outcomes are consistent with Evans et al. (2020) and Freeman et al. (2019), who found that although educators understand the potential of integrating civic and environmental education, the use of data to drive environmental inquiry remains underdeveloped. This suggests a missed opportunity to cultivate environmentally literate citizens capable of interpreting and acting on environmental data. This gap weakens alignment with Constructivist Learning Theory, which advocates for experiential learning where students engage with real-world data to address authentic problems. A constructivist approach to environmental education would see students using data to explore topics like pollution or climate change, guided by teachers who themselves are data-literate and civically engaged. From the lens of Digital Citizenship Theory, the integration of environmental activism into digital civic education is crucial for promoting democratic participation and environmental stewardship. The moderate findings suggest that while teachers value civic education, its application in fostering environmental consciousness via digital platforms is not yet fully realized.

Implications for Educational Practice and Environmental Awareness

The findings of this study have important implications for teacher preparation, curriculum design, environmental education, and policy development. Firstly, the moderate level of data literacy among in-service teachers highlights the urgent need for targeted professional development. Training programmes should be designed to enhance teachers' abilities to analyse and apply data effectively for instructional decision-making, thereby promoting evidence-based teaching practices. Secondly, the limited integration of civic engagement within digital contexts into classroom practice reveals a significant gap in both pre-service and in-service teacher education. Curriculum developers and educational authorities could prioritize the inclusion of digital citizenship, focusing on ethical online behaviour, civic responsibility, and environmental advocacy, as a fundamental element of teacher preparation. Thirdly, systemic barriers such as inadequate digital resources, insufficient training opportunities, and curriculum constraints present ongoing challenges. Addressing these issues requires a coordinated effort from school leadership, policymakers, and stakeholders to ensure that schools are equipped with the necessary infrastructure and support systems to implement 21st-century teaching competencies effectively. Fourthly, the findings emphasize the critical role of civic and data literacy in fostering environmental awareness. Incorporating real-world environmental issues into lessons through civic-oriented and data-driven projects could enhance students' critical thinking skills and empower them to engage in meaningful environmental action. Conclusively, advancing educational practice calls for systemic reforms that integrate data literacy, civic engagement, and environmental consciousness into teacher development and classroom instruction. Such reforms are essential to prepare educators and learners to navigate and contribute responsibly within an increasingly complex and digitally connected world.

Limitations of the Study

This study has several limitations. First, its focus on secondary school teachers in Enugu State, Nigeria, restricts the generalizability of findings to other regions with different educational contexts. Second, the reliance on self-reported data may have introduced social desirability bias, potentially affecting the accuracy of responses. Additionally, the exclusive use of quantitative methods limited the depth of exploration into teachers' lived experiences and contextual challenges. Finally, by excluding pre-service teachers, the study does not account for the perspectives of future educators. Future research should consider broader samples, incorporate qualitative methods, and include both in-service and pre-service teachers for a more comprehensive understanding.

Recommendations

Considering the study's findings, several practical recommendations are proposed to strengthen in-service teachers' capacity to integrate data literacy and civic engagement within their instructional practices. First, there is a pressing need for educational authorities, such as ministries of education, school boards, and teacher development agencies, to invest in robust, context-specific professional development programmes. These programmes should focus on equipping teachers with practical skills in data collection, analysis, and interpretation, alongside strategies for embedding civic engagement and digital citizenship into everyday teaching. Second, teacher education institutions should consider revising their curricula to explicitly incorporate content on digital citizenship and civic education in the digital age. Such revisions would better prepare pre-service teachers to understand the ethical, participatory, and environmental dimensions of digital engagement and civic responsibility. Additionally, school administrators should develop supportive policies and ensure that the necessary digital infrastructure is in place to facilitate data-driven and civically engaged pedagogy. Addressing infrastructural gaps such as limited access to digital tools, internet connectivity, and appropriate teaching materials would enable teachers to apply what they learn effectively in practice. Furthermore, teachers should be encouraged and supported to develop interdisciplinary, project-based learning experiences that address real-world environmental issues. These could involve the use of environmental data, civic action plans, or community-based projects, thereby promoting critical thinking, collaboration, and social responsibility among students. Finally, the creation of professional learning communities, both online and offline, should be promoted to facilitate the sharing of best practices, experiences, and challenges. Such platforms would foster collaboration among teachers and support ongoing professional growth in data literacy and civic engagement.

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