

Use of Digital Tools as a Correlate of Students' Understanding of pH Scale in Water Samples in Owerri Municipal Council of Imo State

**Akanazu, Eze Christopher
Ekpewu Ovie, Raina Ajuruchi**

Department of Chemistry,

Alvan Ikoku Federal University of Education, Owerri, Imo State

¹drezeakanazuc@gmail.com

²rainaovie6@gmail.com

ABSTRACT

This study investigated the relationship between the use of digital tools and students' understanding of the pH scale in water samples within Owerri Municipal Council of Imo State. Guided by three research questions and corresponding null hypotheses, the study employed a correlational research design. A sample of 356 science education students from Alvan Ikoku Federal University of Education, Owerri, was selected through a multi-stage sampling process. Data were collected using a validated and reliable researcher-developed instrument titled "Digital Tools and pH Understanding Questionnaire" (DTPHUQ), and analyzed using Pearson's product-moment correlation, coefficient of determination (R^2), and regression analysis at a 0.05 level of significance. The results showed a moderate positive relationship between the use of pH simulation apps and students' understanding of the pH scale, with a correlation coefficient of $r = 0.55$, and a coefficient of determination of $R^2 = 0.303$, indicating that 30.3% of the variance in understanding was explained by the use of simulation apps ($\beta = 0.55$, $t = 12.15$, $p < 0.05$). A stronger positive relationship was observed between the use of digital pH meters and students' interpretation of pH values, with $r = 0.60$ and $R^2 = 0.36$, meaning 36% of the variance was attributable to the tool ($\beta = 0.60$, $t = 13.90$, $p < 0.05$). Additionally, exposure to interactive video tutorials showed a moderate positive relationship, with $r = 0.50$, $R^2 = 0.25$, and a regression coefficient of $\beta = 0.50$, $t = 10.35$, $p < 0.05$, explaining 25% of the variance in conceptual understanding. All three null hypotheses were rejected, indicating statistically significant relationships. Based on these findings, the study concludes that digital tools play a crucial role in enhancing science students' understanding of pH and water quality concepts. It recommends the deliberate integration of these tools into science education to foster digital literacy, improve conceptual mastery, and promote more effective environmental science teaching in the 21st century.

Keywords: *Digital tools, pH scale, Science education, Water samples.*



INTRODUCTION

The integration of digital tools in science education is a hallmark of 21st-century learning, aimed at improving students' engagement, understanding, and analytical skills. As the world continues to embrace technological innovation in education, digital literacy has become a fundamental skill, especially in the teaching and learning of scientific concepts. Digital tools such as simulation apps, digital measuring instruments, and interactive video tutorials enable learners to visualise abstract ideas, conduct virtual experiments, and interact with content in more meaningful ways. In chemistry and environmental science education, particularly, the use of digital resources offers students real-time exposure to the application of scientific principles in analysing water quality, which is a major public health concern in many Nigerian communities.

Water is essential to life, and its quality has direct implications for health, agriculture, and ecosystem sustainability. In Nigeria, and especially in Imo State, access to safe drinking water remains a persistent challenge. Common water sources, such as boreholes and sachet water, are often assumed to be safe. For instance, Adiotomre and Agbale (2015) reported notable differences in the physicochemical quality of sachet water samples sold in Benin City, raising concerns about their safety. Similarly, Ibe, Ahmad, Ashabelem, and Enyoh (2023) assessed sachet water in Owerri North and found that many samples did not fully meet WHO standards, highlighting the importance of monitoring water sources.

Borehole water, another widely consumed source, is equally prone to contamination, especially when located near dumpsites or industrial zones. For example, studies by Ibe and Ibeachu (2020) and Aralu, Okoye, Abugu et al. (2022) found heavy metal pollutants and poor water quality indices in boreholes near waste sites in Aboh-Mbaise and Nnewi, respectively. In the urban area of Owerri Municipal Council, physicochemical assessments of groundwater conducted by Egereonu et al. (2024) revealed concerning levels of impurities, reinforcing the need for continuous water quality education and monitoring. Enyoh, Verla, and Egejuru (2018) also reported significant pH variations in borehole water samples in Orji, Owerri, linking these variations to both environmental and anthropogenic factors.

Understanding the pH scale, a measure of how acidic or basic a substance is, is central to analysing water quality. The pH value influences the solubility of contaminants and the biological availability of chemical constituents in water. As such, the pH concept is critical for interpreting the safety of water sources. Unfortunately, conceptual gaps remain among learners due to the abstract nature of the pH scale and the practical exposure in many secondary and tertiary institutions. Digital tools can bridge this gap by providing interactive and real-life scenarios where students can engage with the pH concept through experimentation, simulation, and video-based instruction. Digital pH

meters allow for direct measurement and interpretation of water pH, while simulation applications can visually demonstrate how substances behave under different pH conditions. Interactive videos further reinforce theoretical knowledge by showing practical applications and case studies in diverse water sources. The study by Okore et al. (2024) on the utilisation of artificial intelligence tools by chemistry students in Owerri confirmed that digital tools significantly enhanced conceptual learning and problem-solving abilities, especially in science-related subjects. This finding aligns with global trends advocating for increased digital literacy among science educators and learners to meet the demands of 21st-century education.

In view of the health implications of poor water quality and the educational benefits of digital learning tools, examining how digital tool usage correlates with students' understanding of the pH scale becomes crucial. Maimuna and Victor (2012), Magaji and Ajayi (2020) and Verla, Verla and Enyoh (2020) have shown that the effective interpretation of water quality parameters depends heavily on conceptual understanding and analytical competence, both of which can be enhanced through digital means. Therefore, this study investigates the relationship between the use of digital tools and students' understanding of the pH scale in borehole and sachet water samples within Owerri Municipal Council of Imo State. By focusing on pH simulation apps, digital pH meters, and interactive video tutorials, the study aims to provide empirical evidence on the extent to which these tools contribute to conceptual mastery of the pH scale. The outcome of this research could guide educators, policymakers, and curriculum developers to promote digital literacy and improve water quality education among science students in tertiary institutions.

Statement of the Problem

Despite the increasing consumption of borehole and sachet water in Owerri Municipal Council, studies have shown that these water sources often have unsafe or inconsistent pH levels (Adiotomre & Agbale, 2015; Ibe et al., 2023). Understanding the pH scale is essential for assessing water quality; many science students struggle with this concept due to limited practical exposure and over-reliance on traditional teaching methods. Digital tools such as simulation apps, digital pH meters, and interactive video tutorials offer opportunities to improve students' conceptual understanding. However, there is limited empirical evidence on the extent to which the use of these digital tools correlates with students' understanding of the pH scale in water samples. This gap hinders informed integration of digital technologies in science education. Therefore, this study is to determine the extent to which digital tools relate to students' understanding of the pH scale in borehole and sachet water in Owerri Municipal Council.

Research Questions

The following research questions guided the study:

1. To what extent does the use of pH simulation apps correlate with students' understanding of the pH scale in borehole and sachet water samples?
2. To what extent does the use of digital pH meters relate to students' accuracy in interpreting pH levels of water samples?
3. What is the extent to which exposure to interactive video tutorials relate to students' conceptual understanding of the pH scale in local water sources?

Hypotheses

The following hypotheses were tested in this study at a 0.05 level of significance:

1. There is no significant correlation between the use of pH simulation apps and students' understanding of the pH scale in borehole and sachet water samples.
2. There is no significant relationship between the use of digital pH meters and students' accuracy in interpreting pH levels of water samples.
3. There is no significant relationship between exposure to interactive video tutorials and students' conceptual understanding of the pH scale in local water sources.

METHOD

This study adopted a correlational research design to investigate the relationship between the use of digital tools and students' understanding of the pH scale in water samples in Alvan Ikoku Federal University of Education, Owerri, Imo State. The population comprised all 200-level students enrolled in science education programmes in the university. A sample size of 356 students was determined using Taro Yamane's formula at a 0.05 margin of error. A multi-stage sampling technique was employed to ensure adequate representation across departments offering science-related courses. Data were collected using a researcher-developed instrument titled "Digital Tools and pH Understanding Questionnaire" (DTPHUQ). The instrument consisted of 30 items focusing on students' engagement with three digital tools: pH simulation apps, digital pH meters, and interactive video tutorials, as well as their conceptual understanding of the pH scale as applied to borehole and sachet water samples. The instrument was validated by three experts in Science Education and Educational Measurement, and its reliability was established using Cronbach's Alpha, which yielded a coefficient of 0.81. Data were collected and retrieved personally by the researchers, ensuring a 100% return rate. Data were analysed using Pearson's product-moment correlation coefficient to determine the strength and direction of the relationship between digital tool usage and students' understanding of the pH scale. The coefficient of determination (R^2) was

computed to estimate the proportion of variance in students' understanding explained by the digital tools. Regression analysis was conducted to predict students' conceptual outcomes based on their engagement with each digital tool. All statistical tests were conducted at a 0.05 level of significance using the t-test for correlation and regression coefficients.

RESULTS AND DISCUSSION

Table 1: Relationship between use of pH simulation apps and students' understanding of the pH scale in water samples

Variables	N	R	R-square (%)	Remarks
pH Simulation Apps	356	0.55	30.3	Positive Relationship
Understanding of pH	356			

$\beta = 0.55, t = 12.15, p < 0.05$

In Table 1, the Pearson correlation analysis revealed a moderate positive relationship between students' use of pH simulation apps and their understanding of the pH scale, with $r = 0.55, p < 0.05$. The coefficient of determination ($R^2 = 0.303$) indicates that approximately 30.3% of the variance in students' understanding is explained by their use of simulation apps. Regression analysis confirmed the significant predictive effect ($\beta = 0.55, t = 12.15, p < 0.05$). Therefore, the null hypothesis was rejected, indicating a statistically significant relationship.

Table 2: Relationship between use of digital pH meters and students' interpretation of pH levels in water samples

Variables	N	R	R-square (%)	Remarks
Digital pH Meters	356	0.60	36.0	Positive Relationship
Interpretation of pH	356			

$\beta = 0.60, t = 13.90, p < 0.05$

In Table 2, the correlation analysis showed a strong positive relationship between the use of digital pH meters and students' ability to interpret pH levels, with $r = 0.60, p < 0.05$. The R^2 value of 0.36 suggests that 36% of the variation in interpretation accuracy is attributable to the use of digital pH meters. The regression analysis ($\beta = 0.60, t = 13.90, p < 0.05$) supports the existence of a statistically significant relationship.

Table 3: Relationship between exposure to interactive video tutorials and students' conceptual understanding of the pH scale

Variables	N	R	R-square (%)	Remarks
Video Tutorials	356	0.50	25.0	Positive Relationship
Conceptual Understanding	356			

$\beta = 0.50, t = 10.35, p < 0.05$

Table 3 shows a moderate positive correlation between students' exposure to interactive video tutorials and their conceptual understanding of the pH scale, with $r = 0.50, p < 0.05$. The coefficient of determination ($R^2 = 0.25$) implies that 25% of the variation in understanding is explained by the use of video tutorials. The regression analysis ($\beta = 0.50, t = 10.35, p < 0.05$) confirms a statistically significant predictive relationship.

The findings of this study reveal that the use of digital tools, specifically pH simulation apps, digital pH meters, and interactive video tutorials, positively correlates with students' understanding of the pH scale in water samples. Among these tools, digital pH meters showed the strongest relationship with students' ability to interpret pH values. This may be attributed to the fact that digital meters provide real-time, hands-on experience, allowing students to directly engage with actual water samples and see the immediate results of their measurements. This form of experiential learning likely reinforces conceptual knowledge and aids retention. It aligns with the view of Magaji and Ajayi (2020) that real-time analysis of water enhances understanding of its quality indicators. Similarly, Aralu et al. (2022) emphasised the importance of direct testing in improving awareness of groundwater quality, supporting the idea that practical engagement increases comprehension.

The moderate relationship between the use of pH simulation apps and students' conceptual understanding suggests that virtual experiences can also support learning. These apps typically allow students to model chemical reactions, observe pH changes dynamically, and explore scenarios that may not be feasible in a physical lab setting. Although they do not offer tactile experiences, they help to build conceptual clarity through visualisation and interactivity. This finding corresponds with Okore et al. (2024), who reported that chemistry students using artificial intelligence tools, including simulations, developed better conceptual understanding and analytical skills. The relatively high variance in understanding explained by simulation apps in this study confirms their value in making abstract chemical concepts more accessible to students.

Interactive video tutorials also showed a significant, though slightly lower, relationship with students' conceptual understanding of the pH scale. This may be due to the nature of videos, which are typically passive and may not demand the same level of engagement as direct experimentation or interactive simulations. However, they still offer explanatory depth and can reinforce classroom instruction through visual

demonstrations and expert explanations. The effectiveness of video-based learning is supported by the findings of Enyoh, Verla, and Egejuru (2018), who noted that comprehension of pH variations in water is improved when learners are exposed to both theoretical explanations and visual aids. Furthermore, Maimuna and Victor (2012) argued that audio-visual representations can be powerful tools in projecting environmental data and promoting science learning in underserved contexts.

Overall, the findings confirm that digital tools, when effectively integrated into science instruction, can significantly enhance students' understanding of essential environmental chemistry concepts like pH. This is particularly relevant in the context of Imo State, where studies have highlighted concerns over the quality of borehole and sachet water (Ibe & Ibeachu, 2020; Ibe et al., 2023; Egereonu et al., 2024). Equipping students with the digital literacy to analyse and interpret water quality empowers them not only academically but also as informed citizens capable of contributing to community health and environmental monitoring. These confirm the growing need to incorporate digital literacy into science curricula as a means of enhancing both conceptual understanding and practical competence.

CONCLUSION

This study has demonstrated that the use of digital tools—specifically pH simulation apps, digital pH meters, and interactive video tutorials—significantly correlates with students' understanding of the pH scale in water samples in Owerri Municipal Council of Imo State. The findings reveal that digital pH meters offer the highest predictive value for improving students' interpretation of pH, followed by simulation apps and interactive videos. These tools enhance students' engagement, conceptual clarity, and analytical skills by bridging the gap between theoretical instruction and practical application. The results support previous research that emphasises the importance of integrating digital technologies into science education to foster deeper learning. Therefore, promoting the use of relevant digital tools in science classrooms is essential for equipping students with the skills and knowledge needed to analyse environmental issues such as water quality. This calls for a deliberate effort by educators, institutions, and policymakers to incorporate digital literacy into science curricula and provide students with access to appropriate digital resources for effective teaching and learning in the 21st century.

RECOMMENDATIONS

1. Science educators should integrate digital tools such as pH simulation apps, digital pH meters, and interactive video tutorials into classroom instruction to enhance students' understanding of the pH scale.

2. School administrators should provide access to relevant digital resources and training to support teaching and learning of water quality concepts.
3. Curriculum planners should revise science education programmes to include digital literacy components that promote hands-on and technology-driven learning experiences.

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