Effects of Computer-Based Concept-Mapping Strategy on Academic Performance of Upper Basic Social Studies Students in Ilorin Metropolis

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DOI: https://doi.org/10.47772/IJRISS.2026.100600665

Received: 10 June 2026; Accepted: 15 June 2026; Published: 01 July 2026

ABSTRACT

The persistent decline and inconsistency in students' academic performance in Social Studies at the Upper Basic level in Nigeria have remained a major concern for educators and policymakers. Although Social Studies is designed to promote civic competence, critical thinking, and responsible citizenship, students' performance in the Basic Education Certificate Examination (BECE) has consistently fallen below expectations. Between 2015 and 2024, the proportion of students attaining Grade A ranged from 6.53% to 20.31%, while substantial proportions remained within the pass and failure categories, indicating persistent deficiencies in conceptual understanding and mastery of the subject. These concerns have been attributed largely to the continued reliance on conventional teacher-centred instructional approaches that provide limited opportunities for active learner engagement.

This study investigated the effect of Computer-Based Concept Mapping (CBCM) on the academic performance of Upper Basic II Social Studies students in Ilorin Metropolis, Kwara State, Nigeria. The study adopted a quasi-experimental pre-test, post-test, non-equivalent control group design within a 2 × 2 factorial design. A multistage sampling procedure was used to select a sample of 86 students, comprising 34 students in the experimental group and 52 students in the control group. Data were collected using the Social Studies Performance Test (SSPT), which yielded a Kuder-Richardson 20 (KR-20) reliability coefficient of 0.82. The data were analysed using mean, standard deviation, and Analysis of Covariance (ANCOVA) at the 0.05 level of significance.

The findings revealed that students exposed to Computer-Based Concept Mapping recorded a higher post-test mean score (M = 67.26, SD = 20.13) than those taught using the conventional instructional approach (M = 46.58, SD = 21.81), indicating a substantial improvement in academic performance among students in the experimental group. The study concluded that Computer-Based Concept Mapping is a more effective instructional strategy for enhancing students' academic performance in Social Studies than the conventional teaching method. It was therefore recommended that Social Studies teachers integrate Computer-Based Concept Mapping into classroom instruction to promote meaningful learning, improve conceptual understanding, and enhance students' academic performance.

Keywords: Computer-Based Concept Mapping, Academic Performance, Social Studies, Instructional Strategy, Upper Basic Education.

INTRODUCTION

Social Studies is a core school subject designed to equip learners with the knowledge, skills, values, and attitudes required for responsible citizenship and effective participation in society. As a discipline, it examines human behavior, social relationships, governance structures, and interactions between individuals and their environment (Odey, 2019). Through Social Studies education, learners are expected to develop civic competence, national consciousness, social awareness, and critical thinking skills. The attainment of these

objectives is strongly influenced by the quality of classroom instruction and the instructional strategies adopted by teachers.

Teaching and learning constitute a fundamental pillar of the educational process, aimed at enriching learners' experiences and promoting meaningful cognitive and social development. Contemporary views of learning emphasize that effective learning occurs when learners actively construct knowledge rather than passively receive information. Jaya (2015) emphasized that successful learning requires students to actively form conceptual connections between new knowledge and prior understanding. This learner-centered perspective underscores the importance of instructional approaches that foster engagement, interaction, and higher-order thinking.

Instructional strategies serve as interactive pathways that involve students directly in the learning process. Effective strategies facilitate learning experiences in ways that enhance understanding, encourage active participation in discussions, and promote critical thinking. In recent decades, educational practice has shifted from predominantly teacher-centered approaches to learner-centered strategies that promote active participation, collaboration, and reflection. Such strategies are particularly relevant in subjects like Social Studies, where conceptual understanding, the interpretation of social phenomena, and critical reasoning are central to learning outcomes (Kerimbayev et al., 2023).

Academic performance remains a primary indicator for evaluating instructional effectiveness; however, in the context of Social Studies, it must transcend mere cognitive mastery of content. While it reflects the attainment of educational objectives (OECD, 2020), true performance in this discipline is manifested in the learner's ability to translate classroom knowledge into responsible behaviors, ethical decision-making, and moral values within the larger society. Recent scholarship emphasizes that learner-centered strategies, such as Computer-Based Concept Mapping, do more than improve test scores; they foster holistic competence, granting students the agency to apply civic values in real-world scenarios (UNESCO, 2021).

Research by Biesta (2022) argues that the qualification function of education (examinations) must be balanced with socialization and subjectification, through which students develop the moral character to act responsibly in their communities. Furthermore, Ahuja and Sharma (2023) assert that when students engage in active knowledge construction, they develop higher levels of social responsibility and emotional intelligence, leading to improved interpersonal behaviors and adherence to societal norms. This suggests that a student's performance is not only recorded in a grade book but is also observed in their civic engagement and ethical conduct. Consequently, this study views academic performance as a multi-dimensional construct encompassing both formal assessment and the external manifestation of prosocial values and citizenship responsibilities (Okolie et al., 2022). Learner-centered instructional strategies that promote active knowledge construction, feedback, and reflection have been found to significantly improve academic performance across subject areas, particularly at the basic education level (UNESCO, 2021).

At the Upper Basic level in Nigeria, learners transition from basic knowledge acquisition to more complex reasoning and independent learning. However, evidence indicates that students' academic performance in Social Studies remains inconsistent, partly due to a continued reliance on teacher-centered instructional methods that limit engagement and critical thinking (Ayodele, 2023; Atieku et al., 2022). These inequalities can significantly impact students' academic performance and learning experiences (UNESCO, 2022; Ekpoto & Adie, 2024).

One learner-centered instructional strategy that has gained increasing attention is concept mapping, especially when integrated with computer technology. Concept maps are visual representations that depict concepts and their interrelationships in a hierarchical and interconnected structure. They consist of concepts, linking words or phrases, and directional connections that explain relationships among ideas (Shamsuddin et al., 2017). Effective concept maps are clearly structured, hierarchically organized, readable, and logically connected, enabling learners to organize knowledge meaningfully (Lin et al., 2017). The integration of computer technology further enhances the instructional value of concept mapping by making it more flexible, interactive, and engaging.

Computer-Based Concept Mapping (CBCM) addresses several limitations associated with traditional paper-based or chalkboard concept maps. Empirical evidence indicates that CBCM is user-friendly and allows learners to easily add, modify, or delete nodes as their understanding develops (Chiou et al., 2017). It also supports peer collaboration and discussion, as learners can share maps digitally and engage in real-time feedback. Additional features, such as map history functions, promote reflection and evaluation, thereby supporting active learning processes. Studies have further shown that CBCM facilitates the synthesis of complex information and enhances students' ability to summarize and organize knowledge more effectively than conventional instructional methods (Hwang et al., 2018).

Despite growing empirical support for learner-centered instructional strategies, reports from examination bodies and educational research have consistently revealed fluctuations and inconsistencies in students' academic performance in Upper Basic School Social Studies. Recent empirical studies conducted in Nigerian secondary schools indicate that persistent reliance on traditional, teacher-centered instructional methods significantly contributes to this trend. For instance, Omojemite (2025) found that students exposed to interactive and learner-centered instructional strategies in Social Studies and Civic Education achieved significantly higher academic performance than those taught using conventional lecture-based methods. Similarly, Atieku et al. (2022) reported that teacher-centered instructional practices limit students' active participation and engagement, thereby negatively affecting learning outcomes and academic performance. Ayodele (2023) further observed that traditional instructional approaches often restrict the development of critical thinking and conceptual understanding, leading to inconsistent achievement levels among junior secondary school students.

Considering the central role of Social Studies in fostering civic responsibility, critical thinking, and social development, there is a compelling need to investigate innovative instructional strategies capable of improving students' academic performance. Empirical evidence across disciplines demonstrates that CBCM enhances conceptual understanding, retention, and academic achievement. For instance, technology-supported concept mapping has been shown to significantly improve students' recognition of concepts and overall learning outcomes compared with conventional instructional methods (Aydin, 2015; Aşıksoy, 2019). Studies in accounting education further revealed that multidimensional computer-based concept maps reduce cognitive load and enhance learning success, retention, and learner satisfaction (Chiou et al., 2020; Tien et al., 2018). Similarly, research in language education reported that students taught argumentative writing using computer concept maps outperformed those taught through traditional approaches (Zarei, 2015).

Within the Nigerian context, quasi-experimental findings indicated that CBCM significantly improves academic performance among pre-service teachers in Economics (Daramola & Gabriel, 2022), while studies in Physics education show that computer-based concept mapping yields comparable or improved learning outcomes relative to other computer-based instructional strategies (Salisu Mamuda et al., 2023). In science education, CBCM has also been found to facilitate students' understanding of complex biological concepts and relationships (Asabe Ramatu, 2023). Collectively, these studies affirm that computer-based concept mapping is an effective strategy for enhancing academic performance and conceptual comprehension across diverse subject areas.

Despite these established benefits, there remains a paucity of empirical studies examining the effectiveness of computer-based concept mapping in Social Studies at the Upper Basic level, particularly within Kwara State. More importantly, limited attention has been given to how such instructional strategies interact with student variables in influencing learning outcomes. This gap necessitates the present study, which investigates the effects of a computer-based concept mapping strategy on the academic performance of Upper Basic Social Studies students in the Ilorin Metropolis, Nigeria.

Statement of the Problem

Social Studies is a value-oriented subject in the Nigerian educational system designed to promote civic competence, social responsibility, and national consciousness through the development of relevant knowledge, skills, and attitudes required for effective participation in society (UNESCO, 2021; UNICEF, 2022; Odey, 2019). An analysis of student results from 2015 to 2024 shows a consistent pattern of high proportions of Pass

and Credit (Grade C) grades alongside relatively low percentages of Grade A. While a large number of students achieve average performance (with Grade C often above 40% and Pass around 30%), only a small proportion attain excellent performance (Grade A metrics remain static between 10% and 13%). These indicators suggest that although many students meet minimum learning expectations, few demonstrate high-level understanding and mastery of core Social Studies concepts.

This baseline distribution highlights limitations in the effectiveness of conventional teacher-centered instructional methods, which fail to adequately promote deep learning and higher-order thinking (Olokooba, 2022). Although innovative approaches such as concept mapping have been found to enhance meaningful learning and improve academic performance in isolated settings (Daramola & Obimiyuwa, 2022; Ugwoke & Ude, 2022), there is limited empirical evidence regarding its implementation within the Ilorin Metropolis of Kwara State. Therefore, this study seeks to investigate the effectiveness of computer-based concept mapping in improving students' academic performance in Social Studies.

Research questions

1. What is the difference between the academic performance of Upper Basic students in the Ilorin Metropolis taught Social Studies using computer-based concept-mapping strategy and those taught using manual concept mapping?

2. What is the difference between the academic performance of male and female Upper Basic students taught Social Studies using computer-based concept-mapping strategy in Ilorin Metropolis?

Research hypotheses

HO_1: There is no significant difference between the academic performance of Upper Basic students in the Ilorin Metropolis taught Social Studies using the computer-based concept-mapping instructional strategy and those taught using manual concept mapping.

HO_2: There is no significant difference between the academic performance of male and female Upper Basic students taught Social Studies using the computer-based concept-mapping strategy in the Ilorin Metropolis.

METHODOLOGY

Research Design

This study employed a quasi-experimental design using a pre-test, post-test non-equivalent control group within a 2 × 2 factorial structure. The design examined the effects of instructional strategy and school location on students' academic performance. This design represents two levels of treatment (computer-based concept mapping using hierarchical and spider modes respectively and concept mapping strategy; and two levels of school location (rural and semi-urban). The illustration of the design is shown in Table 1:

Table 1: Factorial design

Groups	**Pre-test**	**Treatment**	**Post-test**
Experimental Group 1	O_1	CBCM (X_1)	O_2
Control Group	O_1	-	O_2

Population of the Study

The population for this study comprised all 129,482 Upper Basic School students in Kwara State, Nigeria. The target population consisted of 19,765 Upper Basic II (JSS II) students enrolled in 125 government-owned Upper Basic schools within the Ilorin Metropolis of Kwara State. Upper Basic II students were selected

because they possess adequate foundational knowledge of Social Studies, unlike Upper Basic I students who are newly introduced to some curriculum concepts. They are also more suitable for participation than Upper Basic III students, who are typically engaged in preparations for the Basic Education Certificate Examination (BECE). The participants for the study were drawn from intact Upper Basic II classes in the selected schools. One intact class served as the experimental group, while another served as the control group.

Sample and Sampling Techniques

The sample for the study was drawn from the target population of 19,765 Upper Basic II students in 125 government-owned Upper Basic schools across the three Local Government Areas (Ilorin East, Ilorin South, and Ilorin West) that constitute the Ilorin Metropolis, as at 2023 data published by Kwara State Government. A multistage sampling procedure was employed. First, two Local Government Areas were selected from the three Local Government Areas in the Ilorin Metropolis using the simple random sampling technique. Thereafter, two government-owned Upper Basic schools were purposively selected from each of the selected Local Government Areas based on the availability of the required facilities and their suitability for implementing the instructional intervention. From each selected school, one intact Upper Basic II class was selected for participation. The selected schools were then randomly assigned to the experimental or control group through simple randomization. One school in each selected Local Government Area was assigned to the experimental group, while the other served as the control group. Ensuring that both treatment conditions were geographically balanced across different LGAs to minimize contamination effects.

Instrumentation

The instrument used for data collection in this study was a researcher-adapted Social Studies Performance Test (SSPT). The SSPT consists of 30 multiple-choice items derived from the JSS II Social Studies syllabus and scheme of work, directly corresponding to the instructional units active at the time of the study. The instrument was subjected to face and content validation by two experts in Measurement and Evaluation, Social Studies Education, and Curriculum and Instruction. The SSPT was pilot-tested on 20 Upper Basic II students outside the study area, yielding a reliability coefficient of 0.82 using the Kuder–Richardson (KR-20) formula, indicating that the instrument was reliable for the study.

Procedure for Data Collection

The researcher visited the selected institutions to assess available laboratory infrastructure and secure official administrative approval from school authorities to conduct the study. Cooperation was established with the administrative staff and students across all selected sites. The baseline subject teachers were trained as research assistants to deliver either the computer-based concept mapping instructional strategy or the manual concept mapping strategy. The study lasted for four weeks, which encompassed both the training of instructional staff and the implementation of the classroom experiment.

Experimental Procedure and Operationalization of the CBCM Application

The Computer-Based Concept Mapping (CBCM) intervention was implemented using a custom-engineered, client-side web application developed with HTML5, CSS3, and native JavaScript. The digital package was locally hosted on desktop computers within the school laboratories to bypass local internet constraints. The platform organized the Upper Basic II Social Studies national syllabus scheme of work into five interconnected thematic nodes: (1) Accident in the School, (2) Assertiveness, (3) Home Appliances, (4) Saving, and (5) Banks.

The application employed a dual-pane pedagogical layout. The primary pane presented static, expertly structured conceptual hierarchies of the concept map, while the secondary interactive map allowed students to visually engage with reading and writing relational branches of the target topics—such as tracking the "Causes" and "Preventions" of school accidents through structured, click-to-expand graphic sub-nodes. To maintain high instructional accountability, the application featured a real-time progress-tracking structure and a built-in interactive evaluation quiz. Upon completion, the quiz programmatically generated a visual score-

breakdown dashboard detailing candidate performance metrics across all five themes, providing instant, data-driven metacognitive feedback directly to the learner.

Procedure for Data Analysis

Data collected from the pre-test and post-test administrations were scored and prepared for analysis. The research questions were answered using descriptive statistics (Mean and Standard Deviation), while the null hypotheses were tested using the Analysis of Covariance (ANCOVA) via the Statistical Package for the Social Sciences (SPSS) version 26. The significance of the various statistical evaluations was determined at the 0.05 alpha level. ANCOVA was selected specifically to control for potential errors of initial non-equivalence resulting from the utilization of intact classes.

RESULTS AND DISCUSSION OF FINDINGS

Results

Table 1 presents the descriptive statistics for pre-test and post-test Social Studies performance scores by instructional group. Students in the experimental group, taught using the computer-based concept-mapping (CBCM) strategy, recorded a higher mean post-test score (M = 67.26, SD = 20.13, n = 34) than students in the control group taught using the conventional method (M = 46.58, SD = 21.81, n = 52), an unadjusted mean difference of approximately 20.68 points.

Table 1: Descriptive Statistics for Pre-test and Post-test Scores by Instructional Group

Group	**n**	**Pre-test M (SD)**	**Post-test M (SD)**
Experimental (CBCM)	34	51.18 (21.77)	67.26 (20.13)
Control (Conventional)	52	46.83 (17.74)	46.58 (21.81)

Table 1b: Descriptive Statistics for Pre-test and Post-test Scores by Group and Gender

Group	**Gender**	**n**	**Pre-test M (SD)**	**Post-test M (SD)**
Experimental	Female	21	45.71 (21.75)	68.57 (18.20)
Experimental	Male	13	60.00 (19.46)	65.15 (23.54)
Control	Female	33	46.33 (18.34)	50.97 (21.53)
Control	Male	19	47.68 (17.11)	38.95 (20.67)

Hypothesis One (Ho_1)

Ho_1 stated that there is no significant difference between the academic performance of upper basic students taught Social Studies using the computer-based concept-mapping strategy and those taught using manual/conventional concept mapping. A one-way Analysis of Covariance (ANCOVA), with pre-test score as covariate, was conducted to test this hypothesis. The result showed a statistically significant effect of instructional strategy on students' post-test academic performance, $F(1, 83) = 20.45$, $p < .001$, partial $\eta^2 = .198$ (Table 2). After adjusting for initial differences in pre-test scores, students taught using CBCM had a significantly higher adjusted mean post-test score (67.59) than those taught using the conventional method (46.36). **Ho_1 is therefore rejected.** The covariate (pre-test score) was not a statistically significant predictor of post-test performance in this sample (b = -0.12), indicating that the observed gain was attributable to instructional strategy rather than to pre-existing differences in prior knowledge.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VI June 2026

Table 2: ANCOVA Summary for Post-test Scores by Instructional Strategy, Controlling for Pre-test Scores

Source	SS	df	MS	F	p	Partial η²
Group (adjusted)	9151.79	1	9151.79	20.45	<.001*	.198
Residual	37144.29	83	447.52			

Hypothesis Two (Ho_2)

Ho_2 stated that there is no significant difference between the academic performance of male and female upper basic students taught Social Studies using the computer-based concept-mapping strategy. ANCOVA, controlling for pre-test scores, was conducted within the experimental (CBCM) group to compare adjusted post-test means for female (n = 21) and male (n = 13) students. The result showed no statistically significant difference in post-test performance between female students (adjusted M = 67.62) and male students (adjusted M = 66.69), $F(1, 31) = 0.015$, $p = .903$, partial $\eta^2 = .0005$ (Table 3). **Ho_2 is therefore retained (not rejected).** A supplementary 2 × 2 factorial ANCOVA (instructional strategy × gender) across the full sample (N = 86) corroborated this result, showing a non-significant gender main effect, $F(1, 82) = 2.85$, $p = .095$, and a non-significant strategy × gender interaction, $F(1, 81) = 1.08$, $p = .301$, indicating that the effectiveness of the CBCM strategy did not differ meaningfully between male and female students.

Table 3: ANCOVA Summary for Post-test Scores by Gender within the CBCM Group, Controlling for Pre-test Scores

Source	SS	Df	MS	F	p	Partial η²
Gender (adjusted)	6.26	1	6.26	0.015	.903	.0005
Residual	12853.31	31	414.62			

Assumption Checks and Cross-Validation

Prior to interpreting the ANCOVA results, the underlying statistical assumptions were examined. Levene's test confirmed homogeneity of variance for post-test scores across groups, $F = 0.013$, $p = .909$, supporting the validity of the ANCOVA F-test. However, the correlation between pre-test and post-test scores in the full sample was negligible and non-significant ($r = -.054$, $p = .621$), which departs from the conventional expectation that the covariate should be linearly related to the dependent variable. This weak covariate relationship suggests that pre-test performance had limited predictive value for post-test outcomes in this sample, a pattern that may reflect the short instructional interval, the intensity of the treatment, or measurement variability in the test instrument, and is noted here as a limitation for transparency. As a cross-validation check, an independent-samples Welch t-test was conducted on raw gain scores (post-test minus pre-test), which corroborated the ANCOVA finding for Ho_1: students in the experimental group recorded significantly greater gains (M = 16.09, SD = 32.41) than those in the control group (M = -0.25, SD = 28.88), $t(73.1) = 2.39$, $p = .020$. Table 4 summarizes these checks.

Table 4: Summary of Statistical Assumption Checks and Cross-Validation

Assumption / Check	Statistic	Result
Homogeneity of variance (Levene's test, post-test)	F = 0.013, p = .909	Assumption met
Linearity of covariate (pre-test/post-test correlation)	r = -.054, p = .621	Weak/non-significant
Cross-validation: gain-score Welch t-test (Exp vs Control)	t = 2.39, p = .020	Confirms group effect

Discussion of Findings

The finding for Ho_1 indicates that computer-based concept mapping produced significantly greater improvement in Social Studies academic performance than the conventional, teacher-centred method, even after statistically controlling for pre-existing differences in prior achievement. This result lends empirical support to the theoretical premise that concept mapping, particularly when computer-mediated, externalizes the relationships among ideas and promotes active, learner-driven knowledge construction rather than passive reception of content. It directly addresses the instructional limitation identified by Olokooba (2022), who attributed the persistently low proportion of high-grade (Grade A) achievers in Social Studies to the continued dominance of teacher-centred methods that constrain higher-order thinking and deep conceptual understanding.

The magnitude of the effect obtained in this study (partial $\eta^2 = .198$) is reasonably large by conventional benchmarks for educational interventions, suggesting that the observed advantage of CBCM carries practical significance for classroom application, beyond mere statistical significance. This finding is consistent with earlier reports that concept mapping enhances meaningful learning and improves academic performance in other instructional settings (Daramola & Obimiyuwa, 2022; Ugwoke & Ude, 2022). The present study extends this body of evidence into the specific context of Upper Basic Social Studies instruction within Ilorin Metropolis, Kwara State, where such empirical evidence had previously been limited, thereby addressing the contextual gap identified in the statement of the problem.

A plausible explanation for the superiority of CBCM over the conventional method lies in its capacity to combine the established cognitive benefits of concept mapping, namely the visual organisation of related concepts into coherent hierarchical structures, with the interactive and dynamic affordances of computer-based tools. Such tools allow students to manipulate, restructure, and revise concept maps with relative ease, which may deepen engagement and reinforce retention of relationships among Social Studies concepts more effectively than static, manually constructed maps or lecture-based delivery.

The non-significant outcome for Ho_2 indicates that the computer-based concept-mapping strategy benefited male and female students comparably, with neither sex deriving a significantly greater advantage from the intervention. This is a notable equity-related finding: it suggests that the instructional gains associated with CBCM are not contingent on student gender, and that the strategy can reasonably be adopted as a general-purpose instructional approach across mixed-gender Social Studies classrooms without producing differential outcomes. This finding is consistent with a broader pattern in concept-mapping literature in which cognitive and structural learning strategies tend to produce comparable benefits across gender groups, reinforcing the view that well-designed instructional technology can serve as an equitable intervention for improving academic performance regardless of students' gender.

The results provide robust empirical justification for integrating computer-based concept mapping into Social Studies instruction at the upper basic level, as it not only improves academic performance relative to conventional teaching but does so in a manner that benefits male and female students alike. The weak covariate-criterion relationship observed (pre-test to post-test) is acknowledged as a limitation of the design; future replications may consider a shorter test-retest interval, a parallel-forms pre/post instrument, or a larger sample to strengthen the precision of covariate adjustment.

CONCLUSION AND RECOMMENDATION

This study demonstrates that moving away from text-heavy, lecture-based instruction toward technology-mediated visual organizing tools reduces extraneous cognitive load and enhances learner self-efficacy. By demonstrating robust academic gains that transcend student gender boundaries, the digital architecture proves it does not merely record performance outcomes, but actively optimizes the cognitive pathways necessary for mastering complex social concepts. For publication purposes, this study recommends that:

1. The Kwara State Government and educational stakeholders should prioritize the deployment of computer laboratories to Ilorin metropolis schools, as these students show a high "learning elasticity" when exposed to educational technology.

2. Social Studies teachers should adopt computer-based concept mapping in teaching Social Studies concepts at the Upper Basic level.

3. Government and school administrators should provide adequate computer facilities and instructional software to support the use of computer-based concept mapping in schools.

4. Teachers should be trained through workshops and seminars on the effective use of computer-based instructional strategies.

LIMITATIONS OF THE STUDY

1. The study was limited to public Upper Basic schools in Ilorin Metropolis, Kwara State, which may restrict the generalization of the findings.

2. Variations in infrastructure, electricity supply, and digital literacy in other locations were not considered.

3. The study did not employ formal qualitative instruments such as interviews or focus group discussions.

4. Long-term retention of learning outcomes was not assessed due to the absence of delayed post-tests.

5. The weak relationship between pre-test and post-test scores may have reduced the effectiveness of the ANCOVA analysis.

Suggestions for Further Research

1. Similar studies should be conducted in rural and urban schools across different regions of Nigeria.

2. Future research should adopt mixed-method approaches to capture learners' perceptions and experiences.

3. Longitudinal studies should be carried out to assess long-term retention of concepts.

4. Researchers should explore the development of mobile-based concept mapping applications for wider accessibility.

5. Further studies should examine the influence of factors such as socioeconomic status, digital literacy, and school resources on learning outcomes.

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