



## Concept mapping teaching strategies and junior secondary school students' performance in basic science and technology in Akwa Ibom State

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### Abstract

The study evaluated the influence of concept mapping teaching methods on the academic performance of Basic Science and Technology students in Akwa Ibom South Senatorial District. Specifically, it examined the effects of diagrams, hierarchical structures and charts on student learning. Three research questions and three corresponding hypotheses guided the investigation, which adopted a survey research design. The study population comprised 2,736 Junior Secondary Three students, including 1,047 males and 1,689 females, across seventy-two public secondary schools in the district, with a sample of 350 students (150 males and 200 females) drawn from forty randomly selected schools using stratified random sampling. A structured 5-point rating scale questionnaire, validated by three experts in Measurement and Evaluation and Industrial Technology Education, was used for data collection and its reliability was confirmed with a Cronbach alpha coefficient of 0.84. Data were analysed using mean and standard deviation for the research questions and independent-samples t-tests were applied at 0.05 significance level for hypothesis testing. The findings revealed that diagrams, hierarchical structures and charts had a substantial positive influence on students' comprehension, retention and overall academic performance in Basic Science and Technology, with gender differences observed in hierarchical and chart-based methods. The study concluded that concept mapping strategies significantly enhanced learning outcomes in the subject. The researchers recommended that professional development workshops be organised for teachers to strengthen their competence in implementing concept mapping techniques and that schools be provided with appropriate instructional resources, including graphic organisers, flip charts and digital tools, to facilitate interactive, visual and structured learning in Basic Science and Technology.

**Keywords:** Concepts mapping, basic science and technology, academic performance, diagrams, charts, hierarchical structure

### Introduction

The teaching and learning of science subjects remain central to the educational and socio-economic development of any nation, particularly in developing contexts where science and technology are perceived as catalysts for modernisation and innovation. In Nigeria, Basic Science and Technology (BST) was introduced at the junior secondary school level as a subject designed to inculcate scientific literacy, encourage problem-solving and prepare learners for more advanced studies in the physical and applied sciences. The Federal Republic of Nigeria (FRN, 2014) [22] recognises the pivotal role of BST in equipping students with competencies that are indispensable to national development and sustainable human capital formation. However, despite this emphasis, persistent patterns of poor academic performance in BST have continued to be reported in national and regional assessments, raising serious concerns about pedagogical adequacy, the relevance of teaching methods employed and the preparedness of teachers to stimulate meaningful learning in the classroom (WAEC, 2020; AKSME, 2021). This educational dilemma underscores the need to critically examine innovative teaching strategies that could enhance the quality of BST instruction, particularly in regions such as Akwa Ibom South Senatorial District, where educational disparities and systemic challenges remain entrenched.

One of the recurrent challenges facing science education in Nigeria is the overwhelming reliance on teacher-centred approaches, which often reduce students to passive recipients of information rather than active participants in the construction of knowledge. Several scholars, including

Amadioha and Akor (2018, 2019), have argued that an overdependence on the lecture method restricts learner engagement, stifles curiosity and fails to foster the higher-order cognitive skills necessary for problem-solving and creativity. This observation aligns with broader international research which demonstrates that transmissive pedagogies do not effectively nurture deep conceptual understanding, especially in science education where abstract concepts demand active mental engagement (Novak & Gowin, 1984; Ausubel, 1968) [9, 33]. For example, studies conducted in Nigeria by Nworgu and Otum (2013) [21] revealed that the use of traditional expository methods correlates strongly with students' inability to demonstrate lasting understanding of scientific principles, a challenge which inevitably translates into underachievement in national examinations. The persistence of this trend in Akwa Ibom South is particularly troubling, as it undermines the aspirations of the Universal Basic Education programme and, more broadly, the objectives of the National Policy on Education (FRN, 2014) [22].

Theoretical contributions to cognitive learning, particularly those advanced by Ausubel (1968) [9] on meaningful learning and subsequently operationalised by Novak and Gowin (1984) [33] through the development of concept mapping, have provided significant understanding into how science instruction can be transformed into a more active, student-centred process. According to Maduabum and Odili (2019), concept mapping is predicated on the view that knowledge is hierarchically organised in the human cognitive structure and that meaningful learning occurs when new information is consciously linked with existing

relevant concepts. Thus, the technique enables learners to organise ideas visually and hierarchically, thereby reinforcing relationships among concepts while facilitating retrieval and application. Ezugwu et al., (2022) <sup>[20]</sup>, stated that students exposed to concept mapping not only achieve higher test scores but also show greater interest and motivation towards science subjects. Adeyemi (2016) and Udeani (2017) <sup>[24, 30]</sup>, stated that the effectiveness of concept mapping is likely influenced by contextual variables, including teacher competence, resource availability and student readiness.

Ndirika and Ofoegbu (2015) reported that learners exposed to concept mapping developed a greater sense of ownership of the learning process, while Okebukola (2018) noted that the technique is particularly effective in demystifying complex and abstract scientific topics that typically discourage students. These findings showed the growing consensus that effective science instruction requires methodologies that appeal not only to cognitive domains but also to affective and psychomotor dimensions of learning. Furthermore, in societies where gender disparities in science achievement persist, research outcomes have suggested that concept mapping may provide more equitable opportunities by engaging both male and female learners in active construction of knowledge (Ezeudu & Obi, 2012; Offorma, 2014). Nevertheless, empirical evidence in Nigeria regarding gender differentials in the effectiveness of concept mapping remains inconclusive, with some studies reporting no significant difference (Ezugwu *et al.*, 2022) <sup>[20]</sup>, while others indicate marginal advantages for either gender (Udeani, 2017).

It is also important to acknowledge the structural and contextual challenges that mediate the implementation of innovative teaching strategies in Nigeria. Teachers are frequently constrained by inadequate training, limited professional development opportunities, insufficient instructional materials and overcrowded classrooms (Amadioha & Akor, 2019; Emeh & Ekpo, 2020). In Akwa Ibom State, the situation is compounded by rural-urban disparities, infrastructural deficits and inconsistent government support, factors which collectively affect both the quality of teaching and the overall learning environment. As observed by Nworgu (2016) <sup>[17]</sup>, innovative strategies such as concept mapping require adequate preparation and teacher competence to be implemented effectively; otherwise, their potential benefits may not be realised. This implies that any meaningful evaluation of concept mapping effectiveness must take cognisance of these contextual realities in order to provide evidence that is both reliable and actionable.

A further dimension of the discourse lies in the global recognition that twenty-first century science education must transcend rote memorisation and factual recall, aiming instead at the cultivation of critical thinking, problem-solving, creativity and digital literacy (UNESCO, 2017). In this framework, concept mapping resonates strongly with the imperative for learner-centred pedagogies that promote knowledge integration and lifelong learning. International studies, such as those by Nesbit and Adesope (2006), have underscored that concept mapping enhances comprehension and transfer of knowledge across disciplines, a factor which makes it particularly suitable for foundational subjects such as Basic Science and Technology. Yet, as reiterated by African-based research, the translation of such pedagogical

innovations into measurable gains depends heavily on local adaptation, cultural appropriateness and systemic support (Okonkwo, 2020) <sup>[25]</sup>. In light of the foregoing, this study aims to evaluate the effectiveness of concept mapping in improving students' achievement and interest in Basic Science and Technology in secondary schools in Akwa Ibom South Senatorial District.

### **Statement of the problem**

Basic Science and Technology (BST) is designed to serve as the bedrock of scientific literacy in Nigeria, preparing students at the junior secondary level with essential knowledge and skills for further studies in science, engineering and technology. Despite its acknowledged importance, repeated reports from national examinations such as WAEC (2020) <sup>[48]</sup> and state-based assessments (AKSME, 2021) <sup>[8]</sup> revealed that students' performance in BST remains persistently poor. This sustained underachievement not only undermines the aspirations of the Federal Republic of Nigerian National Policy on Education (FRN, 2014) <sup>[22]</sup> but also raises serious questions about the effectiveness of instructional practices currently adopted in schools. One of the principal reasons advanced for these dismal outcomes is the overwhelming reliance on teacher-centred approaches, which prioritise rote memorisation and factual recall at the expense of meaningful learning and conceptual understanding (Amadioha & Akor, 2018, 2019). Research has shown that such approaches do not adequately foster creativity, critical thinking, or long-term retention skills required in a knowledge-driven society (Nworgu & Otum, 2013).

Although concept mapping has been identified as a promising learner-centred instructional strategy capable of promoting meaningful learning by visually organising and linking related concepts (Ausubel, 1968; Novak & Gowin, 1984) <sup>[9, 33]</sup>, empirical evidence regarding its effectiveness in Nigeria has produced mixed results (Ezugwu *et al.*, 2022; Adeyemi, 2016; Udeani, 2017) <sup>[2, 6, 17]</sup>. Contextual variables such as gender, school location, and resource availability and teacher competence have been found to mediate the outcomes of innovative teaching strategies, yet limited attention has been paid to these dynamics in Akwa Ibom South Senatorial District. Consequently, there is insufficient empirical evidence to determine whether concept mapping can effectively enhance students' achievement and interest in BST in this specific educational context. The present study therefore seeks to address this gap by evaluating the effectiveness of concept mapping in teaching BST in Akwa Ibom South Senatorial District.

### **Purpose of the study**

Specifically, the Study seeks to:

1. Assess the influence of diagrams as a concept mapping teaching method on the academic performance of students in Basic Science and Technology in Akwa Ibom South Senatorial District.
2. Determine the influence of hierarchical structure as a concept mapping teaching method on the academic performance of students in Basic Science and Technology Akwa Ibom South Senatorial District.
3. Evaluate the influence of chart as a concept mapping teaching method on the academic performance of students in Basic Science and Technology in Akwa Ibom South Senatorial District.

## Research Questions

The following research questions were formulated to guide the study;

1. How does diagrams as a concept mapping teaching method influence academic performance of students in Basic Science and Technology in Akwa Ibom South Senatorial District?
2. To what extent does hierarchical structure as a concept mapping teaching method affect the academic performance of students in Basic Science and Technology in Akwa Ibom South Senatorial District?
3. What effect do charts as a concept mapping teaching method have on the academic performance of students in Basic Science and Technology in Akwa Ibom South Senatorial District?

## Research Hypotheses

1. There is no significant difference in the mean response of students on the influence of diagrams as concept teaching method in Basic Science and Technology in Akwa Ibom South Senatorial District.
2. There is no significant difference in the mean response of students on the influence of hierarchical structure as concept teaching method in Basic Science and Technology in Akwa Ibom South Senatorial District.
3. There is no significant difference in the mean response of students on the influence of charts as concept teaching method in Basic Science and Technology in Akwa Ibom South Senatorial District.

## Review of Empirical Studies

Gabriel, Okechukwu, Abonyi and Ugama (2016) <sup>[24]</sup> investigated the effect of concept-mapping instruction on Basic Science achievement using a quasi-experimental non-equivalent control group design with 122 secondary school students. A validated achievement test was administered and data were analysed using ANCOVA to adjust for pre-intervention differences. Findings revealed statistically significant improvements for the experimental group with no interaction by gender. Strengths included covariate adjustment and validated instruments, while limitations were evident in intact-class sampling and insufficient documentation of implementation fidelity. The study demonstrates the methodological appropriateness of ANCOVA and validated instruments, but its restricted sample and weak fidelity documentation necessitate broader sampling and stricter fidelity checks, which the present investigation intends to incorporate.

Adebisi (2017) <sup>[2]</sup> examined concept mapping in senior secondary Physics using a quasi-experimental pretest–posttest design with 70 learners. A researcher-constructed achievement test was administered at immediate post-test and after a retention interval. Results showed significant gains in both achievement and retention for the mapping group. Methodological merit lies in addressing retention effects, while limitations were evident in small sample size and absence of cluster sampling. This study establishes the durability of concept-mapping benefits, but its restricted scale and disciplinary focus necessitate further evaluation in broader Basic Science and Technology contexts with larger and more representative samples, which the present research addresses.

Danjuma and Bajon (2022) <sup>[15]</sup> assessed the influence of concept mapping on performance in Thermal Energy using

a quasi-experimental design with 60 participants. Achievement was measured with an instrument of acceptable reliability ( $\alpha = 0.74$ ) and data analysed using t-tests. Findings revealed significant improvement in the treatment group and no gender-based differences. Internal validity was strengthened by alignment between treatment and measurement, although generalisability was constrained by the narrow topical focus and limited sample size. The study provides topic-specific validation of concept mapping but does not extend to the broader Basic Science and Technology curriculum while the present research addresses this gap by employing a wider range of BST content in Akwa Ibom South.

Ibok (2020) <sup>[25]</sup> conducted a quasi-experimental pretest–posttest study involving 150 Primary Five pupils, sampled using stratified and simple random techniques. A Basic Science Achievement Test was developed and validated and independent t-tests revealed significant positive effects of concept mapping on achievement, retention and problem-solving skills. Moderating variables such as gender and problem-solving ability were also observed. Strengths included larger sample size and stratified design, whereas limitations were evident in inadequate reporting of teacher preparation and fidelity. The study demonstrates the importance of learner-level moderators but was limited to primary pupils while the present research extends this by focusing on secondary schools and systematically evaluating moderating influences in Akwa Ibom South.

Akpoghol, Ode and Adzape (2025) <sup>[7]</sup> examined concept mapping and student interest using a quasi-experimental design with 286 Upper Basic II students. A validated instrument with strong internal consistency ( $\alpha = 0.97$ ) was employed and ANCOVA results revealed significant improvements in student interest and a gender interaction effect. Methodological strengths included large sample size and psychometric rigour, but the study was limited by single-location implementation and absence of detailed process data. This research highlights the significance of affective outcomes as mediators of achievement, though its geographical and process limitations restrict generalizability while the present study extends this approach by integrating affective and cognitive outcomes in a wider district-level analysis.

## Research Methodology

The research adopted a survey research design. This design was deemed appropriate because it enables systematic collection, organisation and description of data relating to the attributes and responses of a defined population in its natural context (Nworgu, 2015; Johnny, Effiong & Sheik, 2020) <sup>[26, 37]</sup>. A survey design is also suitable for studies evaluating pedagogical approaches such as concept mapping, as it allows the researcher to capture students' perceptions and measurable learning outcomes in real school settings without manipulation of variables. The research was undertaken in the South Senatorial District of Akwa Ibom State, Nigeria, otherwise known as Eket Senatorial District. This zone comprises twelve Local Government Areas, namely: Oron, Mbo, Urue Offong Oruko, Okobo, Udung Uko, Esit Eket, Ibeno, Eket, ONNA, Eastern Obolo, Mkpato Enin and Ikot Abasi. The district is geographically located at latitude 4°39' North of the equator and longitude 7°56' East of the prime meridian (Friday et al., 2024). For the 2023/2024 <sup>[23]</sup> academic session, the

district had a total of seventy-two public secondary schools recognised by the State Ministry of Education (Nwanga, Bassey & Umoren, 2025) [36]. This location was purposively chosen because of its heterogeneous school population and the pressing need for pedagogical improvement in Basic Science and Technology.

The target population consisted of all Junior Secondary Three (JS3) students enrolled in public secondary schools in the study area during the 2023 [40]/2024 session, estimated at 2,736 learners, comprising 1,047 males and 1,689 females. Population in research refers to the entire aggregation of elements or units to which the study intends to generalise its findings (Bornstein, 2013) [13]. The choice of JS3 students was informed by the fact that they represent the final stage of lower secondary education, where mastery of Basic Science and Technology is critical for subsequent scientific literacy. From the population frame, a sample of 350 students (150 males and 200 females) was drawn using stratified random sampling techniques. Stratification was based on gender and school location to ensure representativeness across the twelve Local Government Areas. Forty public secondary schools were randomly selected from the district and in each school, thirty students were proportionately chosen to participate. The final sample was determined with consideration to research precision, representativeness and feasibility (Creswell, 2014) [22].

The principal research instrument was a structured questionnaire developed by the researcher. The instrument was divided into two sections: Section A elicited demographic information of respondents, while Section B contained items measuring perceptions of concept mapping effectiveness in teaching Basic Science and Technology. The instrument was designed with the following response options Strongly Agreed (SA=4.50-5.00), moderately Agreed (MA=3.50-4.49), lowly Agreed (LA=2.50-3.49), Undecided (U =1.50-2.49), strongly Disagreed (SD =1.00-1.49) to the answer research questions. This scaling was selected due to its established reliability in capturing attitudinal dispositions and cognitive evaluations of instructional practices (Bryman, 2016) [24]. To establish content and face validity, the draft questionnaire was subjected to critical review by two experts in Measurement and Evaluation and one specialist in Industrial Technology

Education from the University of Uyo, Akwa Ibom State. The evaluators assessed the clarity, relevance and coverage of the items relative to the research objectives and made recommendations which were incorporated into the final version of the instrument. Expert validation has been widely recognised as an essential procedure to ensure that research tools adequately reflect the construct domains under investigation (DeVellis, 2017) [2].

The reliability of the instrument was determined through a pilot study conducted on twenty students outside the selected schools. Responses were analysed using the Cronbach Alpha technique, yielding an overall internal consistency coefficient of 0.84. This value, which exceeds the 0.70 threshold commonly recommended for social science research, demonstrates that the instrument possessed adequate reliability (Field, 2018) [31]. Data collection was conducted by the researcher with the assistance of three trained research assistants. Official permission was obtained from the Principals of the participating schools. The questionnaires were administered during school hours under the supervision of Basic Science and Technology teachers designated by the Principals. Prior to administration, respondents were provided with an information sheet and a consent form, assuring them of anonymity and voluntary participation. The researcher ensured 100% retrieval rate of the administered instruments, as all distributed copies were completed and returned on the spot. The data were subjected to both descriptive and inferential statistical analyses. Specifically, mean and standard deviation were employed to answer the research questions and determine the extent of agreement on each item. To test the formulated null hypotheses, the independent-samples t-test was employed at the 0.05 level of statistical significance. This approach was considered appropriate because it allows comparison of group means across gender categories while controlling for sampling error (Pallant, 2020) [25].

## Data Analysis and Results

**Research Question 1:** How does diagrams as a concept mapping teaching method influence academic performance of students in Basic Science and Technology in Akwa Ibom South Senatorial District?

**Table 1:** Mean rating of female and male students on influence of diagrams as a concept mapping teaching method in Basic Science and Technology

S/N	Use of Diagrams as a Concept Mapping Teaching Method	Female (N = 15)		Male (N = 15)	
		$\bar{X}_1$	SD <sub>1</sub>	$\bar{X}_2$	SD <sub>2</sub>
1.	Diagrams used in concept mapping help me understand scientific and technological concepts better.	3.50	.73	3.71	.76
2.	I find it easier to remember lessons in Basic Science and Technology when diagrams are used during teaching.	3.67	.55	3.94	.82
3.	The use of diagrams in concept mapping has improved my performance in Basic Science and Technology tests.	3.57	.42	4.58	.73
4.	I feel more confident answering questions in Basic Science and Technology when diagrams are part of the lesson.	3.72	.61	3.80	.59
5.	Diagrams make it easier for me to identify the relationships between different science and technology concepts.	3.85	.82	3.66	.84
Grand Mean and Standard Deviation		3.66	0.63	3.94	0.75

**Note:** SA (4.50 – 5.00), A (3.50 – 4.49), N (2.50 – 3.49), D (1.50 – 2.49), SD (1.00 – 1.49).

The data in Table 1 showed that both female and male students reported that diagrams as a concept mapping strategy positively affected their academic achievement in

Basic Science and Technology. Female students' mean scores ranged from 3.50 to 3.85, with a grand mean of 3.66 (SD = 0.63), indicating that diagrams improved

comprehension, retention, confidence and ability to identify relationships among concepts. Male students' mean scores ranged from 3.66 to 4.58, with a grand mean of 3.94 (SD = 0.75), showing stronger effects on comprehension, recall, test performance and self-efficacy. The highest mean score (M = 4.58) among males was for improved test performance, reflecting significant learning outcomes. Since the grand means for both groups fell within the "Agree" range (3.50–4.49), the findings provided evidence that

diagram-based concept mapping enhanced cognitive processing, retention and relational understanding in Basic Science and Technology.

**Research Question 2:** To what extent does hierarchical structure as a concept mapping teaching method affect the academic performance of students in Basic Science and Technology in Akwa Ibom South Senatorial District?

**Table 2:** Mean rating of female and male students on the influence of hierarchical structure as a concept mapping teaching method in Basic Science and Technology.

S/N	Hierarchical Structure as a Concept Teaching Method	Female (N = 15)		Male (N = 15)	
		$\bar{X}_1$	SD <sub>1</sub>	$\bar{X}_2$	SD <sub>2</sub>
1.	Using hierarchical structures in concept mapping helps me understand which science and technology concepts are most important.	3.52	.81	4.77	.60
2.	Hierarchical concept maps help me clearly see the connection between general and specific scientific ideas.	3.50	.54	3.51	.89
3.	I retain information longer when it is presented through hierarchical structures in concept mapping.	3.61	.58	4.69	.61
4.	The step-by-step breakdown of complex topics in hierarchical maps helps me better understand scientific processes.	3.80	.73	4.63	.65
5.	The logical sequence in hierarchical concept maps helps me recall facts more effectively during exams.	3.58	.42	3.54	.73
Grand Mean and Standard Deviation		3.60	0.62	4.23	0.70

**Note:** SA (4.50 – 5.00), A (3.50 – 4.49), N (2.50 – 3.49), D (1.50 – 2.49), SD (1.00 – 1.49).

The data in Table 2 showed that both female and male students indicated that the use of hierarchical structures as a concept mapping strategy influenced their academic achievement in Basic Science and Technology. Female students' mean scores ranged from 3.50 to 3.80, with a grand mean of 3.60 (SD = 0.62), showing agreement that hierarchical maps enhanced understanding of key concepts, improved retention, clarified relationships between general and specific ideas and aided comprehension of complex processes. Male students' mean scores ranged from 3.51 to 4.77, with a grand mean of 4.23 (SD = 0.70), reflecting stronger effects on comprehension, retention and recall during examinations. The highest mean score (M = 4.77)

among males was for identifying important concepts in science and technology, indicating that hierarchical maps improved cognitive organization and knowledge prioritization. Both grand means fell within the "Agree" range, confirming that hierarchical structures effectively promoted understanding, retention and logical sequencing of scientific knowledge.

**Research Question 3:** What effect do charts as a concept mapping teaching method have on the academic performance of students in Basic Science and Technology in Akwa Ibom South Senatorial District?

**Table 3:** Mean rating of female and male students on the influence of charts as a concept mapping teaching method in Basic Science and Technology.

S/N	Charts as a Concept Mapping Teaching Method	Female (N = 15)		Male (N = 15)	
		$\bar{X}_1$	SD <sub>1</sub>	$\bar{X}_2$	SD <sub>2</sub>
1.	The use of charts in concept mapping helps me understand Basic Science and Technology lessons more easily.	4.69	.51	3.92	.46
2.	I find charts helpful in summarizing key ideas during Basic Science and Technology classes.	3.63	.37	3.54	.41
3.	Charts used in concept mapping make it easier for me to identify patterns and trends in scientific information.	4.44	.64	4.17	.32
4.	Charts help me compare and contrast scientific concepts more effectively.	4.49	.59	4.21	.48
5.	I feel more confident in answering exam questions when I study with chart-based concept maps.	4.05	.52	4.09	.37
Grand Mean and Standard Deviation		4.26	0.53	3.99	0.41

**Note:** SA (4.50 – 5.00), A (3.50 – 4.49), N (2.50 – 3.49), D (1.50 – 2.49), SD (1.00 – 1.49).

The data in Table 3 showed that both female and male students reported that the use of charts as a concept mapping strategy influenced their academic achievement in Basic Science and Technology. Female students' mean scores ranged from 3.63 to 4.69, with a grand mean of 4.26 (SD = 0.53), indicating agreement that charts enhanced comprehension, facilitated summarization of ideas, enabled pattern recognition, improved comparison of concepts and

increased confidence in examinations. Male students' mean scores ranged from 3.54 to 4.21, with a grand mean of 3.99 (SD = 0.41), showing positive effects on understanding, recognition of patterns, comparison of scientific concepts and test performance. The highest female mean score (M = 4.69) was recorded for easier understanding of lessons, reflecting the strong impact of chart-based mapping on cognitive processing. With both grand means falling within

the “Agree” range (3.50–4.49), the findings confirmed that charts effectively enhanced organization, analysis and overall academic performance in BST.

**Hypotheses 1:** There is no significant difference in the mean response of students on the influence of diagrams as concept teaching method in Basic Science and Technology in Akwa Ibom South Senatorial District.

**Table 4:** T-test analysis on the influence of diagrams as concept teaching method and academic performance of Basic Science and Technology students in Akwa Ibom South Senatorial District.

Variables	N	X	SD	df	t-cal	t-value	Dec.
Female	200	3.66	0.63	348	-1.11	±1.960	NS
Male	150	3.94	0.75				

Note: NS = Not Significant

The t-test analysis in Table 4 showed no significant difference in the mean responses of female and male students regarding the influence of diagrams as a concept mapping strategy on academic achievement in Basic Science and Technology. Female students had a mean of 3.66 (SD = 0.63), while males recorded 3.94 (SD = 0.75). The calculated t-value of -1.11 was less than the critical t-value of ±1.960 at 348 degrees of freedom, indicating no significant difference at the 0.05 level. This finding demonstrated that gender did not significantly affect students’ perceptions of diagrams in enhancing comprehension, retention and test performance.

**Hypotheses 2:** There is no significant difference in the mean response of students on the influence of hierarchical structure as concept teaching method in Basic Science and Technology in Akwa Ibom South Senatorial District.

**Table 5:** T-test analysis on the influence of hierarchical structure as concept teaching method and academic performance of students in Basic Science and Technology in Akwa Ibom South Senatorial District.

Variables	N	X	SD	Df	t-cal	t-value	Dec.
Female	200	3.60	0.62	348	-9.36	±1.960	NS
Male	150	4.23	0.70				

Note: NS = Not Significant

The t-test analysis in Table 5 showed a significant difference in the mean responses of female and male students regarding the influence of hierarchical structures as a concept mapping strategy on academic performance in Basic Science and Technology. Female students recorded a mean of 3.60 (SD = 0.62), while males had a mean of 4.23 (SD = 0.70). The calculated t-value of -9.36 exceeded the critical t-value of ±1.960 at 348 degrees of freedom, indicating significance at the 0.05 level. This result showed that male students rated hierarchical structures more highly, confirming that gender significantly influenced perceptions in BST.

**Hypotheses 3:** There is no significant difference in the mean response of students on the influence of charts as concept teaching method in Basic Science and Technology in Akwa Ibom South Senatorial District.

**Table 6:** T-test analysis on the influence of charts as concept teaching method and academic performance of students in Basic Science and Technology in Akwa Ibom South Senatorial District.

Variables	N	X	SD	df	t-cal	t-value	Dec.
Female	200	4.26	0.53	348	4.71	±1.960	NS
Male	150	3.99	0.41				

Note: NS = Not Significant

The t-test analysis in Table 6 showed a significant difference in the mean responses of female and male students regarding the influence of charts as a concept mapping strategy on academic performance in Basic Science and Technology. Female students recorded a mean of 4.26 (SD = 0.53), while males had a mean of 3.99 (SD = 0.41). The calculated t-value of 4.71 exceeded the critical t-value of ±1.960 at 348 degrees of freedom, indicating significance at the 0.05 level. This result showed that female students rated charts more highly, confirming that gender significantly influenced perceptions of chart-based concept mapping in BST.

### Discussion of Findings

The analysis for Research Question 1 revealed that the use of diagrams as a concept mapping strategy positively influenced students’ academic achievement in Basic Science and Technology in Akwa Ibom South Senatorial District. Both female and male students indicated that diagrams enhanced comprehension, supported retention, improved confidence in answering questions and aided recognition of relationships among concepts, with grand means of 3.66 for females and 3.94 for males. The t-test result for Hypothesis 1 showed no significant gender difference ( $t = -1.11$ ,  $df = 348$ ,  $p > 0.05$ ), indicating that perceptions of diagram effectiveness were similar across groups. These findings aligned with Gabriel, Okechukwu, Abonyi and Ugama (2016) [24], who reported improved Basic Science achievement with diagrammatic mapping and Adebisi (2017) [45], who found that visual tools enhanced comprehension and retention in Physics. Likewise, Ibok (2020) [25] observed that graphic organizers improved problem-solving and conceptual clarity among primary learners. Although Akpan (2022) [5] noted that contextual factors may moderate outcomes, the present study demonstrated consistent positive perceptions across genders, confirming that diagrams function as effective cognitive scaffolds for integrative understanding and measurable performance in resource-constrained BST classrooms. The findings for Research Question 2 indicated that hierarchical structures as a concept mapping strategy positively influenced students’ academic achievement in Basic Science and Technology in Akwa Ibom South Senatorial District. Male students reported higher mean ratings ( $M = 4.23$ ) compared to females ( $M = 3.60$ ), suggesting a stronger perceived effect on comprehension, retention and logical sequencing of scientific concepts. The t-test for Hypothesis 2 revealed a statistically significant difference ( $t = -9.36$ ,  $df = 348$ ,  $p < 0.05$ ), indicating that gender moderated perceptions of hierarchical mapping effectiveness. These results aligned with Akpoghol, Ode and Adzape (2025) [7], who found that hierarchical maps enhanced interest and achievement in science, though with gender-related variation. Similarly, Danjuma and Bajon (2022) [15] reported that structured visual representations improved learning outcomes in Thermal Energy, although

gender effects were absent, emphasizing context-specific outcomes. Gabriel *et al.* (2016) <sup>[24]</sup> noted that prior ability and instructional fidelity could shape mapping benefits, implying that male students in this study may have had greater exposure to stepwise representations.

The findings for Research Question 3 showed that charts as a concept mapping method positively influenced students' academic performance in Basic Science and Technology in Akwa Ibom South Senatorial District. Female students reported a higher mean score ( $M = 4.26$ ) than males ( $M = 3.99$ ), suggesting stronger perceived benefits in comprehension, summarisation, pattern recognition, comparative analysis and examination confidence. The t-test for Hypothesis 3 revealed a statistically significant difference ( $t = 4.71$ ,  $df = 348$ ,  $p < 0.05$ ), confirming that gender moderated perceptions of chart effectiveness. These results aligned with Akpoghol, Ode and Adzape (2025) <sup>[7]</sup>, who found that graphic representations improved science outcomes with gender-based differences. Similarly, Ibok (2020) <sup>[25]</sup> observed that visual organisers strengthened retention and problem-solving, supporting the present findings. However, Akpan (2022) <sup>[5]</sup> noted that factors such as prior exposure and instructional fidelity could shape instructional benefits, indicating that gendered differences in this study may partly reflect contextual influences.

### Conclusion

The study established that the use of concept mapping teaching methods including diagrams, hierarchical structures and charts significantly enhanced the academic performance of Basic Science and Technology students in Akwa Ibom South Senatorial District. While diagrams improved comprehension, retention and relational understanding across genders without significant differences, hierarchical structures and charts demonstrated gender-specific effects, highlighting the moderating role of learner characteristics in pedagogical outcomes. The findings corroborated existing empirical evidence that visual and structured instructional strategies facilitate integrative understanding, problem-solving and cognitive organisation, while also addressing contextual challenges such as resource constraints and heterogeneous learner populations. Collectively, these results underscore the efficacy of concept mapping as a pedagogical tool capable of promoting meaningful learning in BST and provide a robust empirical foundation for targeted instructional interventions, curriculum enhancement and teacher professional development in secondary schools in the district.

### Recommendations

Based on the findings of the study, the following recommendations were advanced:

1. Teachers should integrate diagrams consistently in Basic Science and Technology lessons to enhance students' understanding and retention of concepts.
2. Hierarchical concept mapping should be employed with attention to gender differences to maximise comprehension and performance outcomes.
3. Charts should be used strategically to facilitate pattern recognition, comparison of scientific ideas and confidence in answering examination questions.
4. School administrators should provide training and resources to ensure effective implementation of concept mapping strategies across all secondary schools.

5. Curriculum developers should incorporate structured visual instructional tools into the Basic Science and Technology syllabus to promote meaningful and integrative learning.

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