



Effectiveness of Cognitive Conflict Strategy in Improving Conceptual Understanding of Evolution among Senior Secondary School Students in Zamfara State, Nigeria

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ABSTRACT

Misconceptions about evolution can impede students' understanding of natural selection, adaptation, genetic variation and evolutionary relationships. This study compared students' conceptual understanding of evolution after instruction using the Cognitive Conflict Strategy (CCS) and conventional method. It also examined gender differences among students exposed to CCS. A quasi-experimental pretest-posttest control-group design involved 283 SS II Biology students from public secondary schools in Zamfara State, Nigeria. Data were collected using an adapted 30-item, two-tier Evolutionary Misconception Test (KR-20 = 0.84) and analysed using descriptive statistics and ANCOVA at the 0.05 significance level. The study revealed that students taught using CCS recorded a higher mean gain (12.86) than those taught using the conventional method (6.71). ANCOVA showed a statistically significant difference between the two groups, $F_{(1, 280)} = 71.47, p < .001$, partial $\eta^2 = .203$. However, no statistically significant gender difference was found among students taught using CCS, $F_{(1, 143)} = 0.48, p = .490$, partial $\eta^2 = .003$. The study concluded that CCS improve students' conceptual understanding of evolution. It is recommended that Biology teachers incorporate CCS into evolution lessons to help students identify, examine and correct misconceptions.

INTRODUCTION

Biology helps students understand living things, how they function, and how different organisms are related. One of the most important concepts in Biology is evolution, which explains the diversity of life and how populations change over generations. Understanding evolution requires knowledge of genetic variation, inheritance, natural selection, adaptation, common ancestry, and speciation. However, these concepts can be difficult to understand, and students may develop misconceptions that affect their understanding of biological processes.

Misconceptions are ideas that differ from accepted scientific explanations. According to Matazu and Isma'il (2024) misconceptions may arise from everyday experiences, previous lessons, or students' personal interpretations of natural events. For example, some students may believe that organisms develop particular characteristics simply because they need them or that they consciously adapt to changes in their environment. Scientific explanations instead emphasise inherited variation and differences in survival and reproduction over successive generations. Such misconceptions may persist even after formal Biology instruction. Several studies have examined misconceptions about evolution among students. Pazza et al. (2010) investigated evolution-related misconceptions among Brazilian university freshmen, while Yates and Marek (2014) explored factors contributing to misconceptions among high school Biology students. Kummer et al. (2016) examined misconceptions about evolutionary relationships. Other studies have investigated these misconceptions among STEM and non-STEM students and high-achieving secondary school graduates (Archila et al., 2024; Panagou et al., 2024). Matazu and Isma'il (2024) also investigated misconceptions about evolution among Nigerian secondary school Biology students. These studies stress the need to help students develop a more accurate understanding of evolutionary concepts.

One teaching approach that may help address these misconceptions is the Cognitive Conflict Strategy (CCS). This strategy involves presenting students with information, questions, or evidence that challenges their existing ideas. Through discussion, questioning, observation, and evidence-based reasoning, students can examine inconsistencies in their explanations and consider scientifically acceptable alternatives. However, presenting conflicting information alone may not be sufficient. Students need appropriate guidance to evaluate the evidence and revise their initial ideas. Limón (2001), Kang et al. (2004), and Lee and Byun (2012) examined different aspects of cognitive conflict and conceptual learning, while Potvin (2023) reviewed learners' responses to contradictory information.

Previous studies have investigated cognitive conflict-based instruction in different science subjects. Madu and Orji (2015) examined conceptual change in heat and temperature, while Haryono et al. (2021) investigated misconceptions about heat. Makhrus and Busyairi (2022) studied misconceptions about force, and Safo-Adu (2020) examined acid-base misconceptions among pre-service integrated science teachers. Although these studies provide a basis for investigating CCS, its effectiveness in teaching evolution cannot be assumed

from findings in other science subjects. Gender may also be relevant to students' conceptual understanding because male and female students may have different learning experiences, prior knowledge, and opportunities to engage with scientific concepts. Research has examined gender in relation to science learning and conceptual understanding (Rosenlund, 2021; Sagala et al., 2019). However, whether male and female students differ in their understanding of evolution after learning through CCS requires further investigation.

Despite existing research on evolution misconceptions and cognitive conflict in science education, further evidence is needed on the use of CCS to teach evolution among senior secondary school students in Zamfara State, Nigeria. This study therefore compared the conceptual-understanding scores of students taught using CCS with those taught using the conventional method, while controlling for pretest scores. It also examined gender differences among students taught using CCS. Since the male and female experimental groups attended different schools, the findings were interpreted cautiously because school-related differences may have influenced the results.

Statement of the Problem

Students hold misconceptions about evolution, such as believing that organisms develop characteristics simply because they need them (Matazu & Isma'il, 2024). These misconceptions can hinder their understanding of natural selection and other evolutionary concepts. Conventional Biology instruction may not always provide sufficient opportunities for students to examine their existing ideas and correct inaccurate explanations. The CCS has potential to help in addressing this problem by challenging students' prior conceptions and guiding them towards scientifically acceptable explanations. However, its effectiveness in improving conceptual understanding of evolution among senior secondary school students in Zamfara State, Nigeria, requires investigation. Furthermore, whether male and female students differ in their conceptual understanding after exposure to CCS remains unclear. Therefore, this study compared the adjusted posttest scores of students taught using CCS with those taught using the conventional method and examined gender differences among students exposed to CCS, while acknowledging the limitations associated with the four-school design.

Objective of the Study

The main objective of the study was to investigate the effectiveness of the Cognitive Conflict Strategy in improving conceptual understanding of evolution among senior secondary school students in Zamfara State, Nigeria. Specifically, the study sought to:

1. Determine the difference in adjusted posttest conceptual-understanding scores between students taught evolution using CCS and those taught using the conventional method.
2. Determine whether a statistically significant difference exists in adjusted posttest conceptual-understanding scores between male and female students taught evolution using CCS.

Research Questions

The following research questions guided the study:

1. What difference exists in the adjusted posttest conceptual-understanding scores of students taught evolution using CCS and those taught using the conventional method?
2. What difference exists in the adjusted posttest conceptual-understanding scores of male and female students taught evolution using CCS?

Research Hypotheses

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

H₀₁: There is no statistically significant difference in the adjusted posttest conceptual-understanding scores of students taught evolution using CCS and those taught using the conventional method.

H₀₂: There is no statistically significant difference in the adjusted posttest conceptual-understanding scores of male and female students taught evolution using CCS.

REVIEW OF RELATED LITERATURE

Several studies have documented difficulties in understanding evolution and evolutionary relationships. Pazza et al. (2010) investigated misconceptions among Brazilian university freshmen, while Yates and Marek (2014) examined factors contributing to evolution-related misconceptions among high school Biology students. Kummer et al. (2016) investigated misconceptions in tree thinking, which is essential for understanding evolutionary relationships. Aptyka et al. (2022) examined situated learning and the clarification of misconceptions in contextual reasoning about natural selection. Archila et al. (2024) and Panagou et al. (2024) also investigated evolution-related misconceptions among different student populations. In Nigeria, Matazu and Isma'il (2024) examined misconceptions about evolution among secondary school Biology students. These studies highlight the importance of helping students develop scientifically accurate explanations of evolutionary processes.

Conceptual change provides a basis for addressing such misconceptions. It involves modifying, reorganising, or replacing existing explanations with more scientifically adequate understanding. Posner et al. (1982) proposed that conceptual change may occur when learners become dissatisfied with their existing conceptions and encounter alternatives that are intelligible, plausible, and fruitful. Vosniadou (1994, 2013) similarly examined how learners' existing explanatory frameworks influence the development of new understanding. These perspectives suggest that students need more than factual information; they may need to reconsider how they interpret and organise scientific knowledge. However, conceptual change is not always immediate or complete. Students may retain elements of earlier explanations or apply scientific reasoning inconsistently. Potvin et al. (2015) investigated competing accounts of conceptual change, while Potvin (2023) reviewed learners' responses to contradictory information. In evolution education, conceptual change may involve replacing

explanations based on need or intention with explanations grounded in inheritance, variation, differential reproduction, and population-level change.

The CCS is an instructional approach that challenges learners' existing explanations through evidence or information that contradicts their prior conceptions. A typical lesson begins by eliciting students' ideas, presenting conflicting evidence, guiding them to examine discrepancies, developing scientifically acceptable explanations, and applying the revised understanding to new situations. Cognitive conflict should not simply involve surprising students or telling them that their answers are incorrect. Learners need guidance to evaluate evidence, compare explanations, and reconstruct their understanding.

Limón (2001) critically examined cognitive conflict as an instructional strategy for conceptual change. Kang et al. (2004) investigated cognitive conflict in science concept learning, while Lee and Byun (2012) examined its relationship with learners' responses to counterintuitive demonstrations. Their work highlights the importance of understanding how learners respond to contradictory information rather than assuming that conflict automatically produces learning. In teaching evolution, for example, a teacher may challenge the belief that organisms develop characteristics because they need them by presenting evidence about inherited variation and differences in reproductive success. Guided discussion can help students evaluate their initial explanations against the scientific account of natural selection.

Empirical studies have examined cognitive conflict and conceptual-change instruction across several science subjects. Madu and Orji (2015) investigated conceptual change in temperature and heat, while Haryono et al. (2021) examined cognitive conflict instruction for addressing misconceptions about heat. Makhrus and Busyairi (2022) investigated misconceptions about force, and Safo-Adu (2020) examined acid-base misconceptions among pre-service integrated science teachers. Mufit et al. (2020) conducted a meta-analysis of cognitive conflict in physics learning, while Pacaci et al. (2024) synthesised research on conceptual-change strategies in science education. Collectively, these studies provide a basis for investigating instructional approaches that challenge learners' existing explanations. Nevertheless, findings from physics and chemistry cannot automatically establish the effectiveness of CCS in evolution education because evolutionary concepts involve distinct forms of reasoning about inheritance, populations, and changes across generations.

Evolution-specific studies further demonstrate the need to address students' misconceptions. Aptyka et al. (2022) examined situated learning and the clarification of misconceptions about natural selection, while Yates and Marek (2014) investigated factors associated with evolution-related misconceptions among high school students. Matazu and Isma'il (2024) provided evidence concerning secondary school Biology students in Nigeria. However, identifying misconceptions and determining whether a particular instructional strategy improves conceptual understanding are different research concerns. The effectiveness of CCS therefore requires direct investigation using appropriate assessment instruments and research designs.

Gender is another consideration in research on science learning and conceptual understanding. Differences in learning outcomes may vary according to prior knowledge, learning opportunities, classroom experiences, and instructional approaches. Sagala et al. (2019) examined STEM-based learning in relation to gender and physics concept understanding. Rosenlund (2021) investigated gender-related differences in conceptual knowledge in the context of assessment and equity, while François et al. (2026) examined conceptual instruction and gender equity in Swedish upper secondary physics classrooms. Although these studies provide a broader basis for considering gender in science education, they do not establish whether male and female students differ in their understanding of evolution following CCS instruction.

The present study addresses these issues by comparing the conceptual-understanding scores of students taught using CCS with those taught using the conventional method in selected public secondary schools in Zamfara State, Nigeria, while controlling for pretest scores. It also examines adjusted posttest differences between male and female students exposed to CCS.

Theoretical Framework

This study was guided by constructivist learning theory and the conceptual change theory proposed by Posner et al. (1982). Constructivist learning theory views learners as active participants in constructing knowledge by relating new information to their existing knowledge and experiences. Rather than simply receiving information from teachers, students interpret and develop understanding based on what they already know.

This perspective is relevant to evolution education because students may have existing explanations about how organisms acquire characteristics, adapt to environmental conditions, and change over generations. If these ideas are not identified and examined, students may interpret scientific explanations in ways that reinforce their misconceptions. The CCS aligns with constructivist principles by encouraging students to express their ideas, examine scientific evidence, discuss alternative explanations, and reconsider their understanding. The teacher facilitates this process through appropriate learning activities, probing questions, and guided discussion.

The conceptual change theory of Posner et al. (1982) provides a more specific explanation of how learners may revise their existing conceptions. According to the theory, conceptual change may occur when learners become dissatisfied with their existing explanations and encounter alternative conceptions that are intelligible, plausible, and fruitful. This provides a theoretical basis for using cognitive conflict to address misconceptions in evolution.

In this study, CCS helped students examine their existing ideas, evaluate conflicting evidence, and develop scientifically accepted explanations. For example, students who believe organisms develop characteristics because they need them were guided to understand the roles of inherited variation and natural selection. However, conflict alone may not change misconceptions; students need guidance to understand evidence and reconsider their ideas.

METHODOLOGY

Research Design

The study adopted a quasi-experimental pretest-posttest control-group design. This design was used because the investigation involved intact Biology classes rather than individual random assignment. The experimental group received instruction using CCS, while the control group received instruction using the conventional method. Both groups completed the Evolutionary Misconception Test before and after the instructional period.

Experimental	O ₁	X	O ₂
Control	O ₁	C	O ₂

Key: O₁ = pretest; O₂ = posttest; X = Cognitive Conflict Strategy; C = conventional method.

The design permits a comparison of posttest scores while controlling statistically for pretest scores. However, because the instructional conditions were implemented in different schools, the design does not completely separate treatment effects from school-level differences.

Population of the Study

The population comprised 25,335 SS II students offering Biology in public secondary schools in Zamfara State during the 2025/2026 academic session. The population figures supplied for the study comprised 16,395 male students and 8,940 female students.

Sample and Sampling Procedure

The sample consisted of 283 SS II Biology students selected from four public secondary schools across Gusau, Kaura Namoda, and Talata Mafara educational zones of Zamfara State. A multi-stage sampling procedure was adopted. In the first stage, the three educational zones were included in the study. In the second stage, four public secondary schools were selected: Schools A and D in Gusau, School B in Kaura Namoda, and School C in Talata Mafara. In the third stage, one intact SS II Biology class was selected from each school. Schools A and B constituted the experimental group and received instruction using the CCS, while Schools C and D constituted the control group and received instruction using the conventional method. The experimental group comprised 146 students (78 male from School A and 68 females from School B), while the control group comprised 137 students (63 male from School C and 74 females from School D). The distribution of the sample is presented in Table 3.02.

Table 1: Sample of SS II Biology Students in Zamfara State

Group	Number of schools	Male	Female	Total
Experimental (CCS)	2	78	68	146
Control (conventional method)	2	63	74	137
Total	4	141	142	283

Source: Field data for the study

Instrument for Data Collection

Data were collected using the Evolutionary Misconception Test (EMT), adapted from the instrument developed and validated by Isma'il and Lukman (2026) for diagnosing evolutionary misconceptions among senior secondary school students. The EMT comprised 30 two-tier multiple-choice items covering natural selection, adaptation, genetic variation, common ancestry, speciation, and evidence for evolution. Each item consisted of a first tier assessing students' selected answers and a second tier assessing the reasoning underlying those answers. One mark was awarded only when both the selected answer and its corresponding reason were correct; otherwise, zero was awarded. The maximum obtainable score was 30. Higher scores indicated better performance on the assessment and stronger conceptual understanding of evolution, as reflected in scientifically accurate answers and explanations.

Validity and Reliability of the Instrument

Isma'il and Lukman (2026) reported the development and validation of the original EMT. For the present study, the adapted instrument was reviewed by experts in Biology Education and Science Education to assess the relevance of its items, clarity of wording, and alignment with the study objectives and selected evolutionary concepts. Appropriate revisions were made based on their feedback. The instrument was also pilot-tested among students in a secondary school in Anka that was not included in the main study. Its internal consistency was assessed using the Kuder-Richardson Formula 20 (KR-20), yielding a reliability coefficient of 0.84. This coefficient indicated acceptable internal consistency for the instrument in the pilot sample.

Experimental Procedure

The study lasted six weeks. Week 1 was devoted to the pretest, Weeks 2–5 to instruction, and Week 6 to the posttest. The instructional period comprised four weeks, with two 45-minute lessons per week. Before the intervention, the teachers were oriented to the instructional procedures and lesson content. Both groups studied the same broad evolutionary concepts and were scheduled to receive comparable instructional time. The main difference was the instructional approach.

Students in the experimental group were taught using the CCS, which involved eliciting prior conceptions, presenting conflicting evidence, examining alternative explanations, reconstructing understanding, and applying scientific explanations. The procedure comprised five stages, as illustrated in Figure 1.

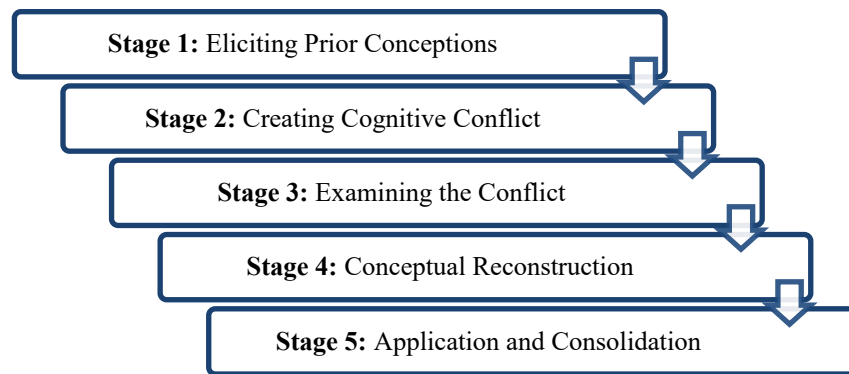


Figure 1: Flowchart of the CCS Instructional Procedure

Source: Researcher's procedure (2026)

In the first stage, the teacher elicited students' prior conceptions of evolution through diagnostic questions and discussions. In the second stage, relevant examples, diagrams, simulations, and scientific evidence were presented to challenge misconceptions. In the third stage, students examined inconsistencies between their initial ideas and the evidence through guided questions and discussions. In the fourth stage, the teacher clarified key evolutionary concepts, including genetic variation, natural selection, adaptation, common ancestry, and changes in populations over generations. In the fifth stage, students applied their revised understanding to new examples and questions to reinforce learning.

Students in the control group were taught using the conventional method, which involved teacher explanations, textbook illustrations, note-taking, question-and-answer sessions, and routine exercises. Although the content and scheduled instructional time were comparable, the lessons were not deliberately organised around the structured sequence of identifying misconceptions, presenting conflicting evidence, and guiding students through conceptual reconstruction.

Both groups completed the same pretest and posttest under the planned assessment conditions to facilitate comparison of their conceptual understanding before and after instruction.

Method of Data Analysis

Research questions were answered using means, standard deviations, and mean gains, while hypotheses were tested using analysis of covariance (ANCOVA) at the 0.05 significance level. Data were analysed using the Statistical Package for the Social Sciences (SPSS).

RESULTS

The results are presented according to the research questions and hypotheses. Higher EMT scores indicate better performance on the diagnostic assessment and were interpreted as evidence of stronger conceptual understanding of evolution.

Research Question One: What difference exists in the adjusted posttest conceptual-understanding scores of students taught evolution using CCS and those taught using the conventional method?

Table 2: Pretest and Posttest Mean Scores by Instructional Group

Group	N	Pretest		Posttest		Mean gain
		Mean	SD	Mean	SD	
Cognitive Conflict Strategy (CCS)	146	11.82	2.63	24.68	2.41	12.86
Conventional method	137	11.75	2.57	18.46	2.95	6.71

Table 2 shows that the CCS group increased its mean score from 11.82 at pretest to 24.68 at posttest, representing a mean gain of 12.86 points. The conventional-method group increased its mean score from 11.75 to 18.46, representing a gain of 6.71 points. The difference in mean gains was 6.15 points in favour of the CCS group. These descriptive results indicate greater improvement in diagnostic-test performance among students in the experimental group.

Hypothesis One (H_{01}): There is no statistically significant difference in the adjusted posttest conceptual-understanding scores of students taught evolution using CCS and those taught using the conventional method.

Table 3: ANCOVA of Posttest Scores by Instructional Group

Source	Sum of squares	df	Mean square	F	p	Partial η^2
Corrected model	1,099.94	2	549.97	40.38	< .001	.224
Intercept	9,428.67	1	9,428.67	692.26	< .001	.712
Pretest	126.38	1	126.38	9.28	.003	.032
Treatment group	973.56	1	973.56	71.47	< .001	.203
Error	3,812.75	280	13.62			
Corrected total	4,912.69	282				

The results in Table 3 show that, after controlling for pretest conceptual-understanding scores, there was a statistically significant difference in adjusted posttest scores between students taught using the CCS and those taught using the conventional method, $F_{(1, 280)} = 71.47$, $p < .001$, partial $\eta^2 = .203$. The partial eta squared value indicates a substantial effect of instructional strategy on conceptual understanding. Since the p-value is less than .05, the null hypothesis is rejected. Therefore, students taught using CCS demonstrated significantly

higher conceptual understanding of evolution than those taught using the conventional method.

Research Question Two: What difference exists in the adjusted posttest conceptual-understanding scores of male and female students taught evolution using CCS?

Table 4: Pretest and Posttest Mean Scores by Gender in the CCS Group

Group	N	Pretest		Posttest		Mean gain
		Mean	SD	Mean	SD	
Male	78	11.90	2.69	24.74	2.46	12.84
Female	68	11.73	2.56	24.60	2.37	12.87

Table 4 shows that male students recorded a mean gain of 12.84 points, while female students recorded a mean gain of 12.87 points. The difference in mean gains was 0.03 points in favour of female students. The descriptive gains were therefore very similar.

Hypothesis Two (H0₂): There is no statistically significant difference in the adjusted posttest conceptual-understanding scores of male and female students taught evolution using CCS.

Table 5: ANCOVA of Posttest Scores by Gender in the CCS Group

Source	Sum of squares	df	Mean square	F	p	Partial η^2
Corrected model	175.81	2	87.91	7.78	< .001	.098
Intercept	4,863.24	1	4,863.24	430.37	< .001	.751
Pretest	170.34	1	170.34	15.08	< .001	.096
Gender	5.47	1	5.47	0.48	.490	.003
Error	1,615.23	143	11.30			
Corrected total	1,791.04	145				

The results in Table 5 show that, after controlling for pretest conceptual-understanding scores, there was no statistically significant difference in adjusted posttest scores between male and female students taught using the CCS, $F_{(1, 143)} = 0.48$, $p = .490$, partial $\eta^2 = .003$. The partial eta squared value indicates a negligible effect of gender on conceptual understanding. Since the p-value is greater than .05, the null hypothesis is not rejected. Therefore, male and female students taught using CCS did not differ significantly in their conceptual understanding of evolution.

DISCUSSION

The first finding showed that students in the CCS group recorded a greater descriptive mean gain than students in the conventional-method group. The reported ANCOVA also indicated a statistically significant difference in adjusted posttest scores, with an adjusted mean difference of 6.08 points in favour of the CCS group. This finding suggests that CCS may support conceptual understanding of evolution under the conditions examined. The two-tier assessment required students to provide both a correct answer and a corresponding reason. Consequently, higher scores indicate stronger performance on the combined answer-and-reason assessment rather than merely the selection of correct answers. One possible explanation is that the CCS instructional sequence encouraged students to examine their existing

explanations and compare them with scientific evidence. Students who initially interpreted adaptation or natural selection in terms of need or intention may have been encouraged to reconsider these explanations through discussion of inherited variation and differential reproductive success. The combination of diagnostic questioning, discrepant evidence, guided reasoning, and application of revised explanations may have supported conceptual learning.

This interpretation is consistent with Posner et al.'s (1982) conceptual change theory, which emphasises dissatisfaction with an existing conception and the development of an intelligible and plausible alternative. It is also consistent with constructivist approaches that recognise the influence of prior knowledge on learning. Nevertheless, the present study did not directly measure students' reasoning processes during instruction. The proposed mechanism should therefore be treated as a plausible explanation rather than a demonstrated mediator of the observed difference.

The finding is broadly consistent with studies examining cognitive conflict instruction in other areas of science. Madu and Orji (2015) investigated conceptual change in temperature and heat, Haryono et al. (2021) examined misconceptions about heat, and Makhrus and Busyairi (2022) investigated a cognitive-conflict approach to misconceptions about force. Safo-Adu (2020) also examined cognitive conflict instruction in relation to acid-base misconceptions. These studies support the relevance of approaches that explicitly address learners' existing explanations. The finding also relates to the broader evidence on conceptual-change strategies discussed by Mufit et al. (2020) and Pacaci et al. (2024). However, evidence from other scientific topics does not establish that all cognitive-conflict approaches will produce the same results in evolution education. The effectiveness of the approach may depend on the quality of instructional materials, the nature of the concepts, teacher facilitation, and students' responses to the evidence.

The present study also addresses a problem documented in evolution education research. Pazza et al. (2010), Kummer et al. (2016), and Yates and Marek (2014) investigated difficulties and misconceptions associated with evolutionary understanding. Aptyka et al. (2022) examined situated learning and clarification of misconceptions concerning natural selection. Matazu and Isma'il (2024) provided evidence from Nigerian secondary school students. The current findings add a comparison of instructional groups from selected public schools in Zamfara State. However, an important qualification concerns the research design. The experimental and control groups attended different schools, and only four schools participated. Differences in teachers, school environments, prior instruction, or other contextual conditions may have contributed to the observed treatment-group difference. Consequently, the result should be interpreted as evidence of an association between instructional condition and posttest performance under the study conditions, rather than conclusive proof that CCS alone caused the improvement.

The second finding showed no statistically significant difference in adjusted posttest scores between male and female students in the experimental group. The reported adjusted means were 24.71 and 24.63, respectively, and the

ANCOVA result was not statistically significant. The descriptive mean gains were also similar: 12.84 points for male students and 12.87 points for female students. These results indicate that the sampled groups recorded comparable numerical improvements. However, a nonsignificant difference does not establish that male and female students are equivalent in their response to CCS. Demonstrating equivalence would require an appropriate equivalence-testing procedure and a justified equivalence margin. One possible interpretation is that the instructional activities offered students opportunities to explain their ideas, examine evidence, discuss alternative interpretations, and reconsider their understanding. Such activities may support participation in conceptual learning. However, the study did not measure participation patterns or the mechanisms through which students engaged with the intervention. This interpretation therefore remains tentative.

Research on gender and science learning has examined conceptual knowledge and achievement across different educational contexts. Sagala et al. (2019) investigated gender differences in STEM-based physics learning, while Rosenlund (2021) examined gender-related differences in conceptual knowledge in the context of assessment and equity. François et al. (2026) explored conceptual instruction and gender equity in Swedish upper secondary physics classrooms. These studies provide a broader context for considering gender, but their findings cannot directly determine how gender relates to evolution learning under CCS.

Limitation of the Study

The main methodological limitation is that the male and female students in the experimental group attended different schools. School characteristics, teacher practices, prior learning experiences and other background conditions may therefore be associated with the observed scores.

CONCLUSION

The study investigated differences in conceptual understanding of evolution between students taught using the Cognitive Conflict Strategy and those taught using the conventional method. It also examined gender differences among students who received CCS. The reported findings showed that the CCS group recorded a greater descriptive mean gain and a higher adjusted posttest mean than the conventional-method group. These results suggest that CCS may support conceptual understanding of evolution by providing opportunities for students to examine prior conceptions, evaluate scientific evidence, and develop more scientifically acceptable explanations. The gender analysis did not detect a statistically significant difference in the posttest scores between male and female students in the experimental group.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

1. Biology teachers in Zamfara State and other parts of Nigeria should use CCS to address students' misconceptions about evolution through scientific evidence and guided discussions.
2. Teacher education institutions should train pre-service and practising Biology teachers in applying CCS to improve students' conceptual understanding of evolution.
3. The Zamfara State Ministry of Education and other relevant education authorities should provide instructional materials that support effective teaching of evolution.
4. Future researchers should investigate CCS effectiveness across more schools in Zamfara State and other Nigerian states, accounting for school-level differences.

AUTHORS' CONTRIBUTIONS

Akilu Isma'il conceived the study, developed the instrument, supervised data collection, analyzed the data, and wrote the manuscript. **Mujidat Lukman Olatunbosun** assisted with data collection, data organization, and manuscript review. Both authors approved the final manuscript.

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