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OBSERVED IMPLEMENTATION OF STUDENT-CENTRED LEARNING IN SENIOR SECONDARY SCHOOL BIOLOGY CLASSROOMS IN BAUCHI STATE, NIGERIA

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ABSTRACT

This study examined the observed implementation of student-centred learning (SCL) in Biology classrooms in public senior secondary schools in Bauchi State, Nigeria. A quantitative structured classroom-observation design was adopted. The wider study involved a population of 500 Biology teachers, from whom 222 were selected using Yamane's formula for the survey phase. Of these, 217 provided usable responses. Subsequently, 32 teachers were purposively selected across three SCL-knowledge bands for classroom observation. Each teacher was observed once during a regular Biology lesson using the researcher-developed Student-Centred Learning Observation Schedule (SCLOS), which comprised 27 indicators across eight dimensions. The observations were conducted by the researcher and two trained research assistants. Three doctoral-level experts assessed the instrument's face and content validity. Pilot testing involving 12 observation records yielded a Cronbach's alpha coefficient of .964 across the 27 indicators. The overall SCL implementation mean was 2.9873 (SD = 0.50596), significantly higher than the study-specific midpoint of 2.50, $t(31) = 5.448$, $p < .001$, Cohen's $d = 0.963$. Feedback and reflection recorded the highest dimension mean (M = 3.2969), whereas use of technology recorded the lowest (M = 1.9844) and was the only dimension below the midpoint. The findings indicate that observed SCL implementation was generally above the scale midpoint, although implementation varied across the eight dimensions. Professional development should therefore strengthen teachers' use of varied instructional strategies and address the practical conditions that support technology integration.

Keywords: student-centred learning, Biology education, classroom observation, instructional practices, secondary schools, Nigeria

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Introduction

Student-centred learning (SCL) shifts the emphasis of teaching and learning actibities from predominantly teacher-directed explanation towards learners' active participation in constructing and applying knowledge (Bremner, 2021; Klemenčič et al., 2020). It includes practices such as inquiry, discussion, collaboration, problem-solving, practical investigation, reflection and the connection of classroom content to real-life contexts. The teacher remains central to the learning process, but the role changes from being the principal source of information to facilitating, guiding and assessing students' learning (Bremner, 2021).

Biology provides opportunities for student-centred approaches through observation, experimentation, investigation, discussion of biological processes and the application of scientific concepts to everyday situations. These opportunities do not, by themselves, demonstrate that SCL is being implemented. The extent to which teachers use such practices needs to be examined in the classroom. Structured observation is useful for this purpose because it records teaching and learning behaviours as they occur, rather than relying solely on teachers' accounts of their own practice.

Evidence from Nigeria indicates that the adoption of learner-centred approaches is shaped by classroom realities and by the relationship between educational expectations and established instructional practices. Oyewole's (2017) qualitative study of secondary schools in south-west Nigeria used classroom observations and stakeholder accounts to examine the implementation of student-centred instruction. The study identified differences between the principles of SCL and classroom practice, while drawing attention to teachers' and students' beliefs and the wider school context. In Rivers State, Ahiakwo and Oko-Jaja (2023) reported limited use of activity-based learner-centred instruction in secondary school Biology. Their study focused on instructional approach and students' performance rather than multidimensional observation of classroom practice.

Recent study has also identified challenges in the enactment of student-centred and practical Biology teaching. Oladipo et al. (2025) examined Biology teachers' pedagogical orientations and practices in under-resourced laboratory settings and reported teacher-centred tendencies alongside constraints associated with time, class size, curriculum demands and resources. These studies provide important context, but they do not replace the need for structured observational evidence examining several dimensions of SCL in senior secondary Biology classrooms in Bauchi State.

Other studies provide more recent observational evidence from Biology classrooms. The study by Odionye and Onyegegbu (2022) examined interaction patterns in SS2 practical Biology lessons in senior secondary schools in Awka Education Zone. Using a modified Flanders interaction instrument, they reported teacher-dominated interaction and lower participation by girls. Although their study focused on interaction styles rather than the broader set of SCL dimensions examined here, it offers directly relevant evidence about the balance of teacher and student participation in practical Biology lessons. At a broader level, Ugwuanyi et al. (2026) analysed teaching-style data from Nigerian science teachers in 1983/1984 and 2023. Their 2023 analysis identified profiles ranging from teacher-led instruction to student-centred and exploratory practice. The study provides recent national context for changes in science teaching, although its teacher data and latent-class approach differ from direct lesson observation using the SCLOS.

Studies conducted in some Africa countries also provide relevant empirical context related to this study. One good example is the study by Otara et al. (2019) who examined

teachers' attitudes towards learner-centred pedagogy in public primary schools in Rwanda, while Rugambwa et al. (2022) investigated the contribution of school-based professional development to learner-centred pedagogical practices in Tanzanian secondary schools. These studies draw attention to the influence of teachers' professional learning and school context on the enactment of learner-centred approaches. Their geographical and methodological contexts differ from those of public senior secondary Biology classrooms in Bauchi State.

Statement of the problem

A distinction exists between understanding SCL and demonstrating student-centred practices during actual instruction. Some studies of teaching practices in Nigerian secondary schools have relied on questionnaires to obtain teachers' perceptions or reports of instructional practices (Ahiakwo & Oko-Jaja, 2023; Okedeyi et al., 2013). Although such instruments provide useful information about reported practices, they do not necessarily establish what occurs during classroom instruction. Research comparing teachers' reported perceptions with classroom observations has demonstrated the value of using multiple sources of evidence to understand actual teaching practices (Schuh, 2004). There is also a need for dimension-specific observational evidence because a single overall score may conceal areas of strength and weakness. Classroom observation offers a means of examining teaching and learning activities as they occur, including learners' participation and interactions within the classroom (Mitchell & Milligan, 2023). This study addresses that need by examining observed SCL implementation across eight dimensions in public senior secondary Biology classrooms in Bauchi State, Nigeria.

Purpose, research questions and hypothesis

The purpose of this study was to examine the extent of observed SCL implementation among Biology teachers in public senior secondary schools in Bauchi State. It was guided by the following two research questions:

1. What is the overall extent of observed SCL implementation among the sampled Biology teachers?
2. What are the mean observed implementation scores for each of the eight dimensions of the SCLOS?

The following null hypothesis was tested at the .05 level of significance:

H_{01}: The mean observed SCL implementation score among the sampled Biology teachers does not differ significantly from the study-specific reference value of 2.50 on the four-point SCLOS scale.

Theoretical and conceptual framework

The study was informed by the Concerns-Based Adoption Model (CBAM), which conceptualises the implementation of educational change as a process that develops over time. CBAM considers teachers' concerns about an innovation, their levels of use and the characteristics of the innovation as enacted in practice (Hall & Hord, 2015). In this study, CBAM provided a broad conceptual context for understanding the implementation of SCL as an educational innovation. However, neither the Levels of Use nor Innovation Configurations component was operationalised in the study. CBAM was not used as a measurement instrument, and teachers were not assigned to CBAM stages or implementation configurations. Instead, SCL implementation was operationalised as observable classroom practice across eight SCLOS dimensions: classroom environment, instructional strategies, student engagement, assessment practices, the teacher's role in facilitating learning, use of technology, feedback and reflection, and community and real-world connection. Each indicator was rated on a four-point scale from 1

(Weak) to 4 (Excellent). These dimensions provided the basis for describing the different aspects of SCL evident in the observed lessons.

Related empirical literature and contribution

Empirical studies related to the current study conducted in Nigeria have examined student-centred instruction and classroom practices in secondary school science, including Biology. The qualitative study by Oyewole (2017) conducted secondary schools in south-west Nigeria. It used classroom observations and stakeholder accounts to examine the implementation of student-centred instruction and the findings of the study identified differences between the principles of student-centred instruction and classroom realities, drawing attention to the influence of teachers' and students' beliefs and the wider school context.

In a similar research, Odionye and Onyegegbu (2022) examined interaction patterns in SS2 practical Biology lessons across 18 intact classes in six secondary schools in Awka Education Zone. The researchers used a modified Flanders interaction instrument, they revealed teacher-dominated classroom interaction and lower participation by girls in the classroom activities. Although their study provides direct observational evidence from Biology classrooms, its focus was on classroom interaction patterns rather than the broader dimensions of SCL implementation as was the focus of the current study.

Other studies conducted examined learner-centred and practical Biology teaching using different approaches. Ahiakwo and Oko-Jaja (2023) investigated the effect of a learner-centred instructional approach on students' performance in secondary school Biology in Rivers State. Their study provides subject-specific evidence on learner-centred instruction, although it did not examine observed classroom practices across multiple dimensions of SCL.

Oladipo et al. (2025) examined Nigerian Biology teachers' pedagogical orientations and practices in under-resourced laboratory settings and reported teacher-centred tendencies alongside constraints associated with resources, time, class size and curriculum demands. At a broader level, Ugwuanyi et al. (2026) analysed changes in teaching styles among Nigerian science teachers and identified different instructional profiles, including teacher-led, student-centred and exploratory approaches. However, their analysis relied on teacher data and a latent-class approach rather than structured observation of individual Biology lessons.

Study from outside Nigeria also provides relevant empirical context. The study by Otara et al. (2019) examined teachers' attitudes towards learner-centred pedagogy in Rwandan public schools, while Rugambwa et al. (2022) investigated the contribution of school-based professional development to learner-centred pedagogical practices in Tanzanian secondary schools. These studies draw attention to the conditions that influence the enactment of learner-centred approaches, including teachers' professional learning and the school context. Nevertheless, their geographical and methodological contexts differ from those of public senior secondary Biology classrooms in Bauchi State.

The existing Nigerian studies provide evidence of teacher-centred interaction, constraints on practical Biology teaching and the use of learner-centred approaches. However, the studies reviewed do not provide the same form of structured, dimension-specific observational evidence across the range of SCL practices examined in the present study. In particular, there remains a need to examine how classroom environment, instructional strategies, student engagement, assessment practices, teacher facilitation, technology use, feedback and reflection, and community and real-world connections are demonstrated during Biology lessons. The present study addresses this need by using the Student-Centred Learning Observation Schedule (SCLOS) to examine these eight dimensions in public senior secondary Biology classrooms in Bauchi

State. Its contribution lies in providing a differentiated account of observed SCL implementation rather than treating classroom practice as a single, undifferentiated outcome.

Methodology

Research design

The study employed a quantitative structured classroom-observation design. This design was appropriate because the study sought to document the extent to which specified SCL practices were demonstrated during regular Biology lessons. No instructional treatment was introduced, and no variable was experimentally manipulated. The analysis reported in this article is restricted to the SCLOS classroom-observation data relevant to the stated research questions and hypothesis.

Population, sampling and sample

The target population comprised 500 Biology teachers in public senior secondary schools across 258 schools in the 20 local government areas (LGAs) of Bauchi State. The schools were distributed across the three education zones: Central, Katagum and Bauchi. A multistage sampling procedure was used. First, the population was organised by education zone. Second, Yamane's (1967) formula, at a .05 level of precision, was used to determine a sample of 222 teachers. The population comprised 132 Biology teachers in Central Zone, 147 in Katagum Zone and 221 in Bauchi Zone. Proportional allocation produced sample allocations of 59, 65 and 98 teachers, respectively. Third, simple random sampling was used to select Biology teachers within each zone. Of the 222 teachers approached, 217 provided usable responses to the wider quantitative instruments, giving a usable response rate of 97.75%.

The 32 teachers observed for this study were purposively selected from the 217 respondents on the basis of their Biology Teachers' Knowledge of Student-Centred Learning Test (BTKSCLT) scores. Selection covered three study-defined SCL-knowledge bands: below 50% (n = 8), 50–69% (n = 14) and 70% and above (n = 10; see Appendix II). The observed teachers came from schools in 11 LGAs: Ningi, Misau, Darazo and Ganjuwa in Central Education Zone; Toro, Bogoro, Tafawa Balewa and Bauchi in Bauchi Education Zone; and Katagum, Giade and Shira in Katagum Education Zone. The observation subsample comprised 10 teachers from Central, 12 from Bauchi and 10 from Katagum Education Zones. Where two Biology teachers in the same school met the selection criteria, both were included. Thus, the 32 observed teachers did not necessarily represent 32 separate schools. The observation subsample was purposively selected rather than probability-based; findings are interpreted as evidence from the lessons observed, not as estimates of the prevalence of SCL practices among all Biology teachers in Bauchi State.

Instrumentation

Data were collected using the Student-Centred Learning Observation Schedule (SCLOS), developed by the researcher by adapting and synthesising indicators from classroom-observation resources, including the Reformed Teaching Observation Protocol (RTOP; Sawada et al., 2002) and Bielefeldt's (2012) discussion of the use of classroom observation to inform technology decisions. The SCLOS was tailored to the study's focus on Biology teaching in public senior secondary schools. It was not an unchanged version of any one source instrument.

The SCLOS contained 27 indicators distributed across eight dimensions: classroom environment (4 indicators), instructional strategies (6), student engagement (5), assessment practices (3), the teacher's role in facilitating learning (3), use of technology (2), feedback and reflection (2), and community and real-world connection (2). Each indicator was rated on a four-point scale: 1 = Weak, 2 = Moderate, 3 = Good and 4 = Excellent. For each teacher, dimension

scores were calculated as the mean of the indicators within that dimension. The overall composite score was calculated as the mean of all 27 indicator ratings.

Validity and reliability

The SCLOS underwent face and content validation by three doctoral-level experts in relevant education and measurement fields. Their review considered the relevance, clarity and suitability of the indicators for observing SCL implementation in Biology classrooms, and recommendations were incorporated before the main data collection. The SCLOS was pilot-tested in selected public senior secondary schools across the three education zones of Bauchi State. The schools and Biology teachers involved in the pilot were excluded from the main study. Internal consistency was examined using 12 pilot observation records. Cronbach's alpha was .964 across the 27 indicators and is reported as the principal internal-consistency estimate because it corresponds to the complete indicator set used to calculate the overall score. A supplementary analysis of the eight dimension-mean variables produced an alpha of .942 and a standardised alpha of .950. Both estimates are preliminary because they were based on only 12 records. They describe internal consistency in the pilot data and do not establish agreement between observers.

Three observers participated in the pilot and main observation phases: the researcher and two research assistants. Before data collection, the researcher trained the assistants on the eight SCLOS dimensions, the 27 indicators, the four-point rating scale and the recording procedure. Training involved explanation of the indicators, demonstration and practice rating, and discussion of rating differences. During the pilot, each observer rated four separate Biology lessons, producing 12 observation records. The observers did not independently rate the same lessons. The pilot design therefore did not permit estimation of inter-rater agreement. Although SPSS generated intraclass correlation coefficients, these were not interpreted as inter-rater reliability estimates because the observers rated different lessons. No valid inter-rater reliability coefficient was obtained.

Observation procedure and ethical considerations

The main classroom observations were conducted between June and July 2026. Each of the 32 teachers was observed once during a regular Biology lesson, with each observation lasting approximately 35–40 minutes. Three observers participated in the data collection. The researcher observed teachers in Bauchi Education Zone (12 teachers); the first trained research assistant covered Central Education Zone (10 teachers); and the second trained research assistant covered Katagum Education Zone (10 teachers). The assistants had been trained by the researcher before data collection. Ratings were recorded using the SCLOS. Because each teacher was observed on one occasion, the data represent a single-lesson account of classroom practice.

Access to the participating schools was facilitated through an introductory letter issued by the Department of Science Education, Abubakar Tafawa Balewa University (ATBU). The letter was used to seek administrative approval from the Bauchi State Ministry of Education and the Directors of Education in the three education zones. Approval was subsequently granted by the Honourable Commissioner for Education, Bauchi State, and the approval document served as the official authorisation for conducting the study in public senior secondary schools across the state. In accordance with the University's established procedure, no additional research ethics clearance was required. Verbal informed consent was obtained from participating Biology teachers after the purpose and procedures of the study had been explained. Participation was voluntary, and teachers were informed of their right to withdraw at any stage without penalty.

Confidentiality was maintained through participant codes, password-protected electronic files and secure storage of hard-copy records.

Data analysis

The observation data were analysed using IBM SPSS Statistics, version 27. Means and standard deviations were calculated to describe the overall implementation of student-centred learning (SCL) and the scores for each of the eight SCLOS dimensions. For each teacher, dimension scores were computed as the arithmetic mean of the indicator ratings within the respective dimension. The overall implementation score was calculated as the arithmetic mean of all 27 indicator ratings, with each indicator contributing equally to the composite score.

The Shapiro–Wilk test was used to assess the normality of the overall composite scores before conducting the one-sample t-test. The result ($W = .945$, $p = .103$) indicated no statistically significant departure from normality. A one-sample t-test was then conducted to determine whether the overall mean implementation score differed significantly from the study-specific reference value of 2.50, which represents the midpoint of the four-point SCLOS rating scale. The test was evaluated at the .05 significance level. The mean difference and its 95% confidence interval were reported, alongside Cohen's d as an estimate of the standardised difference from the reference value. Research Question 2, which examined the implementation scores across the eight SCLOS dimensions, was answered descriptively using their respective means and standard deviations. No inferential test was applied to the dimension scores because the research question sought to describe the observed levels of implementation across the dimensions rather than test differences between them.

Results

The results in Table 1 show that the 32 observed teachers recorded an overall SCL implementation mean of 2.9873 (SD = 0.50596). A one-sample t-test indicated that this mean was significantly higher than the study-specific reference value of 2.50, $t(31) = 5.448$, $p < .001$. The mean difference was 0.48727, with a 95% confidence interval of [0.3049, 0.6697]. The standardised mean difference was large (Cohen's d = 0.963). These results addressed null hypothesis H_{01}, which stated that the mean observed SCL implementation score did not differ significantly from 2.50. Since the p-value was below the .05 significance level, H_{01} was rejected. This indicates that the observed level of SCL implementation was significantly higher than the study-specific midpoint of the four-point SCLOS scale

Table 1

One-sample t-test of overall observed SCL implementation

N	Mean	SD	Test value	Mean difference	95% CI of difference	t	df	p	Cohen's d
32	2.9873	0.50596	2.50	0.48727	[0.3049, 0.6697]	5.448	31	< .001	0.963

Note. The test value of 2.50 is the study-specific midpoint of the four-point SCLOS scale. Cohen's d is reported as the standardised mean difference.

The results in Table 2 show variation in the mean scores across the eight dimensions of observed SCL implementation. Feedback and reflection recorded the highest mean (M = 3.2969, SD = 0.64582), followed by community and real-world connection (M = 3.2344, SD = 0.72939) and the teacher's role in facilitating learning (M = 3.1979, SD = 0.75662). Student engagement (M = 3.1375, SD = 0.69177) and assessment practices (M = 3.1354, SD = 0.57958) also recorded mean scores above 3.00. Instructional strategies (M = 2.9167, SD = 0.46180) and classroom environment (M = 2.8594, SD = 0.60554) recorded mean scores above the study-specific

midpoint of 2.50. Use of technology had the lowest mean (M = 1.9844, SD = 0.82779), making it the only dimension with a mean score below the midpoint. The overall mean for SCL implementation was 2.9873 (SD = 0.50596)

Table 2

Mean scores for the eight dimensions of observed SCL implementation (N = 32)

SCLOS dimension	Mean	SD
Classroom environment	2.8594	0.60554
Instructional strategies	2.9167	0.46180
Students' engagement	3.1375	0.69177
Assessment practices	3.1354	0.57958
Teacher's role in facilitating learning	3.1979	0.75662
Use of technology	1.9844	0.82779
Feedback and reflection	3.2969	0.64582
Community and real-world connection	3.2344	0.72939
Overall Mean of SCL Implementation	**2.9873**	**0.50596**

Note. *The 2.50 reference value is the study-specific midpoint of the four-point scale.*

Discussion

The overall mean indicates that observed SCL implementation was above the study-specific midpoint of the four-point scale. The composite score was calculated by averaging the 27 indicator ratings for each teacher and then calculating the mean across the 32 observed teachers. This result suggests that the observed lessons displayed a generally favourable level of the practices captured by the SCLOS.

The pattern also has a close point of comparison with Odionye and Onyegegbu (2022), who observed teacher-dominated interaction in practical Biology lessons in Awka Education Zone. Their findings point to limited student participation in some practical lessons, whereas the present study recorded dimension means above the reference point for student engagement and several facilitative practices. The difference should be interpreted cautiously because the studies used different observation frameworks, locations and samples. Ugwuanyi et al. (2026) provide a broader, more recent perspective from Nigerian science education. Their analysis of 2023 teacher data identified student-centred and exploratory teaching as one of several instructional profiles, alongside teacher-led and less-engaged profiles. This supports the view that teaching approaches in Nigeria are varied rather than uniform. However, their study used teacher data and latent-class analysis, so it does not independently validate the level of SCL observed in the present Biology lessons.

The result is consistent with the view that SCL implementation needs to be examined through classroom practice rather than inferred from policy statements or teachers' reported knowledge. Oyewole (2017) identified differences between the principles of student-centred instruction and classroom realities in Nigerian secondary schools. The present study adds structured, dimension-specific observation from senior secondary Biology classrooms in Bauchi State. The findings also complement Ahiakwo and Oko-Jaja's (2023) report of limited use of activity-based learner-centred instruction in Biology in Rivers State. The studies differ in design and measures, so their findings are related evidence rather than directly equivalent estimates.

Feedback and reflection recorded the highest mean. This suggests that, among the dimensions assessed, the observed teachers more frequently demonstrated practices associated with responding to learners' contributions and supporting reflection. Community and real-world connection and the teacher's role in facilitating learning also recorded comparatively high

means. Otara et al. (2019) found that teachers' attitudes towards learner-centred pedagogy in Rwandan public primary schools were shaped by the realities of translating learner-centred intentions into classroom practice. Rugambwa et al. (2022), in Tanzanian secondary schools, identified a contribution of school-based professional development to learner-centred pedagogical practices. The present study complements these findings by providing direct observation of eight SCL dimensions in Nigerian senior secondary Biology lessons. The studies differ in country, school level and method, and should not be treated as direct replications. The current results describe the lessons observed and do not establish how consistently these practices occur across teachers' full teaching schedules.

Technology use recorded the lowest mean and was the only dimension below the study-specific midpoint. This finding is consistent with concerns in Nigerian Biology education about the conditions under which practical and technology-supported learning takes place. Oladipo et al. (2025) reported teacher-centred tendencies and constraints associated with resources, time, class size and curriculum demands in under-resourced laboratory settings. Bielefeldt (2012) also emphasised the value of classroom observation in informing decisions about technology use. The present study did not measure school infrastructure, resource availability or teachers' technology competence as explanatory variables. It is therefore not possible to determine from these data why technology-related practices were less evident.

Instructional strategies and classroom environment also recorded lower means than the strongest dimensions, although both were above 2.50. These results suggest that the observed lessons did not demonstrate the same level of performance across all aspects of SCL. This uneven pattern is compatible with CBAM's view that implementation of an educational innovation may vary across its components and over time (Hall & Hord, 2015). However, the study did not measure teachers' concerns or levels of use under CBAM. The framework therefore helps interpret the uneven pattern but does not provide a basis for assigning implementation stages to the participating teachers.

Implications of the study

Professional development for Biology teachers should address the dimensions that received comparatively lower ratings, particularly instructional-strategy diversity and technology use. Training should move beyond describing SCL principles and provide opportunities for teachers to plan, rehearse and receive feedback on inquiry, collaborative learning, practical investigation and problem-solving activities. The comparatively strong ratings for feedback and reflection, teacher facilitation and real-world connection can provide a basis for peer demonstration and professional learning.

Education authorities and school leaders should also examine the availability and suitability of teaching resources before attributing low technology use to individual teachers. Appropriate support may include access to functional equipment, relevant digital materials and practical guidance on selecting technology that serves the learning objectives of a Biology lesson. These implications are recommendations arising from the observed pattern; the present study did not test the effectiveness of any professional-development or resource intervention.

Limitations of the study

The observation phase involved 32 teachers selected across SCL-knowledge bands from the 217 respondents in the wider survey. The observed subsample was not designed to provide state-wide prevalence estimates. Each teacher was observed once for approximately 35–40 minutes, which limits the extent to which the ratings represent their usual classroom practice and leaves open the possibility of observer effects. Although three observers were trained, they rated

different lessons, so inter-rater reliability could not be estimated. The pilot Cronbach's alpha represents internal consistency across the indicators and was not interpreted as evidence of inter-rater agreement. The midpoint of 2.50 was a study-specific analytical reference rather than an externally validated threshold for good implementation. The dimension-level descriptive findings should be interpreted with appropriate caution.

Conclusion

Observed SCL implementation among the 32 Biology teachers was significantly above the study-specific midpoint of the four-point SCLOS scale (M = 2.9873, SD = 0.50596). The dimension means showed uneven implementation. Feedback and reflection recorded the highest mean, whereas use of technology recorded the lowest and was the only dimension below the midpoint. The findings demonstrate the value of examining SCL through direct classroom observation and identifying the dimensions that require further instructional and institutional support.

Recommendations

1. The Bauchi State Ministry of Education and relevant education authorities should organise practice-based professional development that helps Biology teachers plan and implement inquiry, collaborative, problem-solving and practical-investigation activities.
2. School leaders and heads of department should encourage peer observation and professional discussion focused on the effective practices identified in the observed lessons, particularly feedback, teacher facilitation and connections between Biology concepts and real-world contexts.
3. Education authorities and school management should assess the availability, functionality and suitability of instructional resources and technology in Biology classrooms before attributing low technology integration to teachers' competence or motivation.
4. Future studies should involve larger and more diverse observational samples, repeated observations of each teacher and independent double-rating of a proportion of lessons. Appropriate inter-rater statistics, such as an intraclass correlation coefficient or weighted kappa where suitable, should be reported.
5. Further research should examine school-level conditions associated with technology integration and the implementation of student-centred instructional strategies in Biology classrooms.

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Appendix I. Student-centred learning observation schedule (SCLOS): Indicators and scoring

SCL implementation rating scale

Score Category Descriptor

4 Excellent Consistently demonstrates a wide range of student-centred practices, including inquiry, collaboration, and learner autonomy, with clear alignment to SCL principles.

3 Good Frequently demonstrates student-centred practices, though with minor inconsistencies or limited depth in some areas.

2 Moderate Demonstrates occasional use of student-centred strategies, but implementation is inconsistent and lacks depth or integration.

1 Weak Rarely or does not demonstrate student-centred practices; teaching remains predominantly teacher-centred.

Dimension	**Indicator**	**Rating (1–4)**
1. Classroom environment	Classroom arrangement encourages collaboration.	1 2 3 4
	Learning resources and materials are available.	1 2 3 4
	Student work is displayed to foster ownership.	1 2 3 4
	The teacher creates a positive and inclusive learning atmosphere.	1 2 3 4
2. Instructional strategies	Inquiry-based learning is incorporated.	1 2 3 4
	Hands-on activities (e.g., experiments and models) are used.	1 2 3 4
	Student-led discussions are facilitated.	1 2 3 4
	Group work and collaboration are encouraged.	1 2 3 4
	Experiential learning is implemented.	1 2 3 4
	Project-based learning is used.	1 2 3 4
3. Student engagement	Students actively participate in discussions and tasks.	1 2 3 4
	Students demonstrate curiosity and critical thinking.	1 2 3 4
	Students take responsibility for their own learning.	1 2 3 4
	Students ask questions.	1 2 3 4
	Students seek clarification when they do not understand instruction.	1 2 3 4
4. Assessment practices	Formative assessments (e.g., questioning and quizzes) are used.	1 2 3 4
	Self-assessment or peer feedback is encouraged.	1 2 3 4
	Performance-based assessments (e.g., presentations and laboratory reports) are included.	1 2 3 4

5. Teacher's role in facilitating learning	The teacher encourages student questioning and exploration.	1 2 3 4
	The teacher adapts lessons to students' needs and interests.	1 2 3 4
	The teacher creates a safe space for student expression.	1 2 3 4
6. Use of technology	Digital tools enhance learning (e.g., simulations and virtual laboratories).	1 2 3 4
	Students use technology for research and collaboration.	1 2 3 4
7. Feedback and reflection	The teacher encourages student reflection on learning.	1 2 3 4
	The teacher uses student feedback to adjust instruction.	1 2 3 4
8. Community and real-world connection	The teacher relates content to real-world applications.	1 2 3 4
	Problem-solving activities based on real-world scenarios are included.	1 2 3 4

Appendix II. Participants field data

Category: 1 = <50.0; 2 = 50.0–69.9; 3 = ≥70.0

Participants' Field Data (N=32)

S/No	Category	BTKSCLT Score (100%)
1.	1	25.00
2.	2	65.00
3.	1	32.50
4.	2	65.00
5.	3	82.50
6.	1	42.50
7.	2	67.50
8.	3	72.50
9.	1	37.50
10.	2	67.50
11.	3	70.00
12.	3	87.50
13.	3	72.50
14.	2	65.00
15.	3	82.50
16.	2	55.00
17.	3	95.00
18.	1	32.50
19.	3	85.00
20.	3	82.50
21.	2	52.50
22.	2	55.00
23.	2	50.00

24.	1	37.50
25.	3	87.50
26.	2	62.50
27.	2	57.50
28.	2	50.00
29.	1	32.50
30.	2	65.00
31.	2	62.50
32.	1	45.00

Note: Biology Teachers' Knowledge of Student-centred Learning Test (BTKSCLT), a criterion used for selecting 32 participants from the 217 respondents