

# Effect of Content-Focused Coaching on Academic Performance and Retention in Identified Difficult Biology Topics amongst Senior Secondary School Students

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**Abstract:** This study investigated the effect of Content-Focused Coaching (CFC) on academic performance and retention in difficult biology topics among Senior Secondary School students in Zamfara State, Nigeria. Quasi-experimental design was adopted for the study. Multi-stage sampling technique was employed to select 1005 students (480 males, 525 females) and 48 teachers from 166 public schools. The Biology Performance Test, with a reliability coefficient of 0.77, was used for data collection. Teacher participants were exposed to CFC for seven weeks, focusing on six identified perceived difficult biology topics. Data collected were analysed using ANCOVA at a 0.05 significance level. Results showed significant differences in performance ( $F(3, 966)=111.394, p<0.05$ ) and retention ( $F(3, 966)=164.035, p<0.05$ ) among students taught by teachers with Pedagogical Content Knowledge and those taught by Biological Content Knowledge-only who were exposed to CFC. Gender differences were observed, with CFC being effective for both genders. Whereas, students taught by teachers with Pedagogical Knowledge-only exposed to CFC did not significantly improved in performance and retention, and showed notable gender differences similar to those taught by teachers in the control group. The study recommended CFC for professional development of biology teachers.

**Keywords:** Content-focused coaching; Difficult biology topics; Academic performance; Retention, Gender

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## 1. Introduction

Although no longer a core subject in Nigerian secondary schools, biology as a subject still attracts more non-science students. This may be due to the importance of the subject and its relevance to modern society. However, according to Bichi et al. (2019) and Oyovwi (2021), the performance of Nigerian secondary school students in the subject has been unsatisfactory. This abysmal trend has attracted the attention of scholars in the fields of biology education, in effort to improve it. Research findings have attributed the prevailing poor performance to several factors. Prominent among these factors are lack of qualify biology teachers (Bichi et al., 2019), ineffective teaching methods (Chukwuemeka & Dorgu, 2019), inadequate teachers' content knowledge (Brunetti et al., 2023), nonchalant attitude towards biology (Ahmad et al., 2022), lack of instructional materials (Matazu, 2022), gender disparity (Ahmad et al., 2022; Anoh & Oyekanmi, 2021), overloaded curriculum content (Ezechi, 2019; Haruna, 2021) among others.

However, research findings (e.g. Abdullahi, 2021; Anoh & Oyekanmi, 2021; Benitez, 2020; Brunetti et al., 2023; Haruna, 2021; Omoseebi, 2021; Wilmot, 2020) have shown that, teachers' lack of Content Knowledge (CK) and Pedagogical Knowledge (PK) have a greater effect on students' learning outcomes than any other factors so far identified.



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This was recently corroborated by the findings of Hamunyela et al. (2022), which revealed that, implementation of biology curriculum faced significant limitations primarily due to teachers' challenges with PK and CK. This implies that biology teachers who lack Biological Content Knowledge (BCK) and PK may find certain topics challenging, leading them to perceive them as difficult. This can result in either ineffective teaching of these topics or intentionally skip them.

Therefore, biology teachers' knowledge bases, encompassing both BCK and PK, are vital in shaping the perception of difficulty of biology topics, which subsequently affects students' performance and retention. Kyado et al. (2019) reported that inadequate understanding of certain biology concepts contributes to student difficulties. Similarly, Haruna (2021) found that the way abstract concepts are taught contributes to students' perceived difficulty. This difficulty in understanding is echoed in the West African Examinations Council (WAEC, 2021; 2022) Chief Examiners' reports which identify topics such as the nervous system, physiological features, and genetics as particularly challenging for students. Previous research (e.g., Edeh & Martha, 2020; Ezechi, 2019; Ozcan et al., 2014) have also found a correlation between students' perception of topic difficulty and poor performance.

Academic performance in biology, which refers to students' knowledge, skills, and understanding measured through tests, is undoubtedly strongly affected by biology teachers' knowledge bases (BCK and PK). Similarly, retention, which relates to the ability to recall or remember learned concepts or past experiences, is also affected by these knowledge bases. Although biology is regarded as a gender neutral subject by Njoku and Nwagbo (2020), the effect of gender on students' learning outcomes has been inconsistent (Musonda, 2021). Consequently, gender has become a factor in students' academic performance and retention in biology, necessitating further research to establish consistent evidence on gender disparities in the subject.

According to Sodangi et al. (2022), insufficient teacher training and a lack of professional development (PD) opportunities have compounded the persistent poor academic performance in science subjects (biology inclusive) in Zamfara State. According to the Zamfara State Secondary Education Assessment Committee [ZSSEAC] (2014), science teachers in the state, including biology teachers, struggle to deliver the curriculum effectively. This, coupled with the perceived difficulty of certain topics (Isma'il & Matazu, 2024), contributes to poor students' learning outcomes in the state. Hence, targeted PD interventions are necessary to tackle these issues.

In line with this, Ifamuyiwa (2022) recommended for more effective PD models for practising teachers. They pointed out limitations of workshops or seminars, which often lack appropriate epistemological frameworks and adhere to traditional designs. Correspondingly, Collins (2021) identified coaching and mentoring as effective PD approaches for improving CK and PK among in-service teachers. Coaching, particularly, has gained prominence over mentoring due to its higher efficacy (Collins, 2021; Weitzel & Blank, 2019). Cornett and Knight (2011) found that teachers who participated in coaching were more likely to adopt new teaching strategies, resulting in improved instructional practices and better student outcomes.

Content-Focused Coaching (CFC) is widely recognized as a promising model among coaching PD approaches for its potential to influence both teachers' instructional methods and student learning (Callard et al., 2020; Gibbons & Cobb, 2016). According to West and Staub (2003), CFC aims to enhance student learning outcomes by enabling teachers to improve their instructional practices within specific content areas. They further stated that, CFC emphasizes lesson planning, implementation, and reflection to meet curriculum demands. Unlike traditional PD, CFC uniquely focuses on subject-specific content and pedagogical methods (West & Staub, 2003). The CFC was originally developed for math and adapted for subjects like English literacy, and more recently for re-training science teachers. It offers significant benefits over other PD

models. Drawing from this background, this study aims to investigate the effect of CFC on academic performance and retention in identified difficult biology topics in Zamfara State.

## 2. Statement of the Problem

Academic performance in biology among students in Zamfara State has consistently been poor, with failure rates ranging from 55% to over 60% (Research and Statistics Unit, Zamfara State 2023), posing a significant concern for the state's education system. The difficulty in effectively teaching certain biology topics is evident (Isma'il & Matazu, 2024). Six topics within SS 1- SS 2 curriculum were identified as difficult. These are Nutrition in animals, Respiratory system, Pests and diseases of crops, Cell and its environment, Functioning ecosystems, and Nutrient cycle in nature. The factors contributing to these challenges are complex, with lack of qualified biology teachers identified as a major issue exacerbated by the lack of PD opportunities. Existing studies in the state prioritize teaching methodologies, but there is a gap in research addressing the PD needs of biology teachers in terms of their BCK and PK. Furthermore, current PD models such as workshops and seminars have shown limitations in effectively improving teachers' CK and PK. Therefore, effective PD interventions targeting these knowledge gaps are necessary to ultimately improve the students' performance in Zamfara State. To this end, the main objective of the study was to investigate the effectiveness of CFC on students' academic performance and retention in challenging biology topics in Zamfara State, Nigeria.

## 3. Null Hypotheses

The following null hypotheses were formulated for the study;

**H<sub>01</sub>:** There is no significant difference in the academic performance in identified difficult biology topics among SS 2 students in the E.G. 1, 2, 3, and the Control Group.

**H<sub>02</sub>:** There is no significant difference in the retention ability in identified difficult biology topics among SS 2 students in the E.G. 1, 2, 3, and the Control Group.

**H<sub>03</sub>:** There is no significant difference in academic performance in identified difficult biology topics between male and female SS 2 students across E.G. 1, 2, and 3.

**H<sub>04</sub>:** There is no significant difference in the retention ability of male and female SS 2 students in identified difficult biology topics across E.G. 1, 2, and 3.

## 4. Methodology

The study adopted quasi-experimental research design involving pre-test post-test experimental – control group design. The population of the study comprised 27,375 SS 2 students and 209 biology teachers in 166 public senior secondary schools across Zamfara State's four Educational Zones. The study employed a multi-stage sampling technique by dividing the population into four clusters, each representing an educational zone.

Three zones, Kaura Namoda, Gusau, and Talata Mafara, were selected. Then, 4 schools were selected per zone through random sampling, totalling 12. From each school, 2 intact classes were randomly selected. Through purposive sampling 16 teachers from each zone were selected based on their knowledge bases (academic qualifications), having a minimum of 5 years teaching experience. The categories are Teachers who possessed Biological Content Knowledge-only (TBCK-only), Teachers who possessed Pedagogical Knowledge-only (TPK-only) and Teachers who possessed Pedagogical Content Knowledge (TPCK). The TBCK-only teachers possess biology content knowledge but lack pedagogical skills. TPK-only teachers have pedagogical skills but limited biology content knowledge. While TPCK teachers possess a balanced expertise in both biology content and pedagogy.

An achievement test consisting of 60 multiple-choice items tagged “Biology Performance Test (BPT)” was constructed by the researcher. The BPT measured SS 2 students’ academic performance and retention in six difficult biology topics from the SS 1 to SS 2 curriculum, as identified by Isma'il and Matazu (2024) in the study area. The topics are Cell and its environment, Nutrition in animals, Functioning ecosystems, Respiratory system, Nutrient cycle in nature, and Pests and diseases of crops. The BPT was validated by three experts. Reliability was assessed using test-retest data from the pilot study, with Pearson Product-Moment Correlation Coefficient, yielding a coefficient of 0.77.

The CFC intervention, was conducted in three phases; Pre-lesson Conference, In-Class Experiences, and Post-Lesson Conference phases. Pre-Lesson Conference: At the start of the CFC, one school per Educational Zone was selected as a Coaching Centre, where the researcher, acting as coach, convened with teacher participants weekly for seven weeks. Teacher participants were categorized into three groups based on their qualifications and all were exposed to CFC. They were designated as TBCK-only exposed to CFC (TBCK-CFC), TPK-only exposed to CFC (TPK-CFC), and TPCK exposed to CFC (TPCK-CFC). These teachers were then assigned to teach student participants in the corresponding E.G. 1, 2, and 3. At this stage also, the researcher enlisted three Assistant Lecturers, experienced in teaching practice supervision, that assisted with follow-up visits and data collection. In-Class Experiences: Collaborative teaching between the researcher (coach) and teacher participants in the three groups, focusing on the six challenging topics, was conducted at this stage. Three approaches were employed: co-planning, the coach teaching, and co-teaching with teacher participants. These sessions focused on improving content and pedagogical skills, adhering to the teaching methodology and resource guidelines of the NERDC (2008) Biology Curriculum. Post-Lesson Conference: At this stage, Follow-up Visits was conducted to observe classroom implementation of coached lessons and providing feedback. Collaborative Reflections followed, where the coach and teachers discussed strengths and weaknesses observed.

The coaching duration spanned seven weeks. During these weeks, teacher participants implemented learned strategies in their classrooms. A control group was included to serve as a baseline for comparison, ensuring observed effects in the experimental groups were due to the treatment. As ethical consideration, the researcher obtained permission from the Zamfara State Ministry of Education to conduct the study. Data collection involved pre-test, post-test and post-post-test (for retention) using the BPT. Analysis of Co-variance (ANCOVA) was used to test all the null hypotheses at 0.05 levels of significance. Bonferroni’s post-hoc test was conducted to identified the experimental condition with significant differences.

## 5. Results

The results of the findings were presented based on the formulated hypotheses.

**H<sub>01</sub>:** There is no significant difference in the academic performance in identified difficult biology topics among SS 2 students in the E.G. 1, 2, 3, and the Control Group.

**Table 1.** ANCOVA Result on Academic Performance among E.G. 1, 2, 3 and CG

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	60774.292a	4	15193.573	95.259	.000
Intercept	54208.405	1	54208.405	339.871	.000
Covariate (Pre-test)	8632.231	1	8632.231	54.122	.000
Treatment	53301.181	3	17767.060	111.394	.000
Error	154074.163	966	159.497		
Total	773041.000	971			

Corrected Total	214848.455	970
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<sup>a</sup> R Squared = .283 (Adjusted R Squared = .280) \*: Significant at  $p < 0.05$   
Source: Research Fieldwork (2023)

ANCOVA analysis in **Table 1** revealed a significant difference in academic performance among SS 2 students across E.G.s 1, 2, 3, and the Control Group ( $F(3, 966) = 111.394$ ,  $p < 0.05$ ), leading to the rejection of  $H_{01}$ . Subsequently, Bonferroni's post-hoc test was conducted to identify the experimental condition with significantly higher performance (see **Table 2**).

**Table 2.** Bonferroni Post-hoc Analysis on Academic Performance among the Groups

(I) Group	(J) Group	Mean Difference (I-J)	Sig.b	95% Confidence Interval for Difference <sup>b</sup>	
				Lower Bound	Upper Bound
E.G. 1	E.G. 2	8.902*	.000	5.856	11.949
	E.G. 3	-7.263*	.000	-10.265	-4.261
	Control Group	11.450*	.000	8.463	14.438
E.G. 2	E.G. 1	-8.902*	.000	-11.949	-5.856
	E.G. 3	-16.165*	.000	-19.245	-13.086
	Control Group	2.548	.169	-.515	5.611
E.G. 3	E.G. 1	7.263*	.000	4.261	10.265
	E.G. 2	16.165*	.000	13.086	19.245
	Control Group	18.714*	.000	15.693	21.734
Ctrl Group	E.G. 1	-11.450*	.000	-14.438	-8.463
	E.G. 2	-2.548	.169	-5.611	.515
	E.G. 3	-18.714*	.000	-21.734	-15.693

Keys: E.G. 1 = Students taught by TBCK-CFC, E.G. 2 = Students taught by TPK-CFC  
E.G. 3 = Students taught by TPCK-CFC, Control Group = Students taught by TN-CFC.  
Source: Researcher's pair-wise comparison \*: Significant at  $p < 0.05$

The post-hoc analysis in Table 1b shows that E.G. 3 outperformed both E.G. 1 ( $M_{diff} = 7.263$ ,  $p < 0.05$ ) and E.G. 2 ( $M_{diff} = 16.165$ ,  $p < 0.05$ ). Additionally, E.G. 1 showed superior performance compared to E.G. 2 ( $M_{diff} = 8.902$ ,  $p < 0.05$ ). Moreover, the Control Group performed significantly lower than both E.G. 1 ( $M_{diff} = -11.450$ ,  $p < 0.05$ ) and E.G. 3 ( $M_{diff} = -18.714$ ,  $p < 0.05$ ).

**H<sub>02</sub>:** There is no significant difference in the retention ability in identified difficult biology topics among SS 2 students in the E.G. 1, 2, 3 and the Control Group.

**Table 3.** ANCOVA Result on Retention Ability among the Groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	59076.385a	4	14769.096	133.662	.000
Intercept	53383.012	1	53383.012	483.123	.000
Covariate (Post-test)	5608.266	1	5608.266	50.756	.000
Treatment	54375.433	3	18125.144	164.035	.000
Error	106738.775	966	110.496		
Total	661736.000	971			
Corrected Total	165815.160	970			

<sup>a</sup>. R Squared = .356 (Adjusted R Squared = .354) \*: Significant at  $p < 0.05$

The ANCOVA analysis in **Table 3** showed a significant difference in retention ability among SS 2 students across E.G.s 1, 2, 3, and the Control Group ( $F(3, 966) = 164.035$ ,  $p < 0.05$ ), thus rejecting the  $H_{02}$ . This indicates the treatment effect on retention abilities across experimental conditions. Subsequently, Bonferroni's post-hoc test was

conducted to identify specific conditions with significantly higher performance (see **Table 4**).

**Table 4.** Bonferroni Post-hoc Analysis on Retention Ability among Groups

(I) Group	(J) Group	Mean Difference (I-J)	Sig.b	95% Confidence Interval for Difference <sup>b</sup>	
				Lower Bound	Upper Bound
E.G. 1	E.G. 2	3.196*	.000	1.206	5.186
	E.G. 3	-3.248*	.000	-5.196	-1.301
	Control Group	5.715*	.000	3.725	7.706
E.G. 2	E.G. 1	-3.196*	.000	-5.186	-1.206
	E.G. 3	-6.444*	.000	-8.574	-4.314
	Control Group	2.519*	.004	.566	4.473
E.G. 3	E.G. 1	3.248*	.000	1.301	5.196
	E.G. 2	6.444*	.000	4.314	8.574
	Control Group	8.964*	.000	6.808	11.119
Control Group	E.G. 1	-5.715*	.000	-7.706	-3.725
	E.G. 2	-2.519*	.004	-4.473	-.566
	E.G. 3	-8.964*	.000	-11.119	-6.808

Source: Researcher's pair-wise comparison \*: Significant at  $p < 0.05$

The Bonferroni Post-hoc analysis in **Table 4** demonstrates significant differences in retention ability among groups ( $p < 0.05$ ). E.G. 3 had the highest retention ability, significantly outperforming E.G. 1 (Mdiff = 3.248) and E.G. 2 (Mdiff = 6.444). E.G. 1 also showed higher retention ability compared to E.G. 2 (Mdiff = 3.196).

**H<sub>03</sub>**: There is no significant difference in academic performance in identified difficult biology topics between male and female SS 2 students in E.G. 1, 2 and 3.

**Table 5.** ANCOVA Result on Academic Performance of E.G. 1, 2, and 3 by gender

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	15909.780a	6	2651.630	14.660	.000
Intercept	149318.844	1	149318.844	825.557	.000
Covariate (Pre-test)	1059.450	1	1059.450	5.858	.016
Treatment * Gender	15563.605	5	3112.721	17.210	.000
Error	129684.016	717	180.870		
Total	988942.000	724			
Corrected Total	145593.796	723			

a. R Squared = .109 (Adjusted R Squared = .102) \*: Significant at  $p < 0.05$

Source: Research Fieldwork (2023)

The ANCOVA results in **Table 5** show a significant difference in academic performance between male and female SS 2 students across E.G.s 1, 2, and 3 ( $F(5, 717) = 17.210$ ,  $p < 0.05$ ), leading to the rejection of **H<sub>03</sub>**. This rejection suggests a significant treatment effect on academic performance based on gender. Subsequently, Bonferroni's Post-hoc test was conducted to identify specific conditions contributing to this difference (see **Table 6**).

**Table 6.** Bonferroni Post-hoc on Academic Performance of E.G. 1, 2, and 3 by gender

(I) Group	(J) Group	Mean Difference (I-J)	Sig.b	95% Confidence Interval for Difference <sup>b</sup>	
				Lower Bound	Upper Bound
E.G. 1 Male	E.G. 2 Female	4.323*	0.002	1.346	7.299
	E.G. 3 Female	-0.285	0.921	-1.093	0.052

E.G. 2 Male	E.G. 1 Female	-4.323*	0.002	-7.299	-1.346
	E.G. 3 Female	-11.005*	0.000	-14.018	-7.992
E.G. 3 Male	E.G. 1 Female	0.203	0.930	-0.391	0.795
	E.G. 2 Female	11.005*	0.000	7.992	14.018

Source: Research Fieldwork (2023) \*: Significant at  $p < 0.05$

**Table 6** revealed significant differences in academic performance between male and female students. E.G. 1 males outperformed E.G. 2 females (Mdiff = 4.323,  $p = 0.002$ ), while E.G. 2 males performed less than E.G. 1 female (Mdiff = -4.323,  $p = 0.002$ ) and E.G. 3 females (Mdiff = -11.005,  $p = 0.000$ ). E.G. 3 males outperformed E.G. 2 females (Mdiff = 11.005,  $p = 0.000$ ). No significant difference was found between genders in E.G.s 1 and 3.

Null Hypothesis Four (H04): There is no significant difference in the retention ability of male and female SS 2 students in identified difficult biology topics across E.G. 1, 2, and 3.

**Table 7.** ANCOVA Result for Retention Ability of E.G. 1, 2, and 3 by Gender

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	67575.366a	6	11262.561	207.143	.000
Intercept	8392.207	1	8392.207	154.351	.000
Covariate (Post-test)	50460.845	1	50460.845	928.083	.000
Gender	3645.914	5	729.183	13.411	.000
Error	38984.037	717	54.371		
Total	782136.000	724			
Corrected Total	106559.403	723			

a. R Squared = .634 (Adjusted R Squared = .631) \*: Significant at  $p < 0.05$

The ANCOVA results in **Table 7** reveal a significant difference in retention ability between male and female SS 2 students across E.G.s 1, 2, and 3 ( $F(5, 717) = 13.411$ ,  $p < 0.05$ ). This led to the rejection of H04. Subsequent post-hoc tests were conducted to pinpoint specific group differences (see **Table 8**).

**Table 8.** Bonferroni Post-hoc Analysis on Retention Ability of E.G. 1, 2, and 3 by Gender

(I) Group	(J) Group	Mean Difference (I-J)	Sig.b	95% Confidence Interval for Differenceb	
				Lower Bound	Upper Bound
E.G. 1 Male	E.G. 2 Female	4.814*	.000	3.183	6.445
	E.G. 3 Female	-.216	1.000	-1.843	1.412
E.G. 2 Male	E.G. 1 Female	-4.814*	.000	-6.445	-3.183
	E.G. 3 Female	-5.030*	.000	-6.749	-3.311
E.G. 3 Male	E.G. 1 Female	.216	1.000	-1.412	1.843
	E.G. 2 Female	5.030*	.000	3.311	6.749

Source: Research Fieldwork (2023) \*: Significant at  $p < 0.05$

The Bonferroni post-hoc analysis in **Table 8** indicates significant differences in retention ability between male and female SS 2 students across E.G.s 1, 2, and 3. E.G. 1 males showed higher retention than E.G. 2 females (Mdiff = 4.814,  $p = .000$ ), while E.G. 2 males exhibited lower retention than E.G. 1 female (Mdiff = -4.814,  $p = .000$ ) and E.G. 3 females (Mdiff = -5.030,  $p = .000$ ). E.G. 2 demonstrated significantly lower performance, with no significant differences between genders in E.G.s 1 and 3.

## 6. Discussion

The results pertaining to the first null hypothesis revealed a significant difference in academic performance in the identified difficult biology topics among SS 2 students in Zamfara State. Particularly noteworthy was the significant improvement observed in the

groups taught by TPCK-CFC and TBCK-CFC. This is consistent with the findings of Ibrahim (2012), who reported impact of effective professional development model in increasing teachers' knowledge bases thereby shaping student achievement. The finding of the present study, revealed the efficacy of CFC, especially for professionally qualified biology teachers and those possessing biology content knowledge but have limited pedagogical skills. In contrast, the TPK-CFC and Control Group exhibited comparatively less gains. This finding resonates with existing literature and also lends credence with previous research by Ololube (2006), Ifamuyiwa (2022), Abdullahi (2021), and Adeniran (2018), Darnell (2020) and Hibbard (2016) who emphasizes the impact of teacher qualifications (knowledge bases) on student learning outcomes. These findings collectively stressed on the significance of effective professional development like CFC in enhancing teachers' mastery of subject matter and instruction skills to ultimately improve students' academic performance.

The analysis of the second hypothesis revealed a statistically significant difference in the retention abilities in identified perceived difficult biology topics among SS 2 students in the Experimental Groups 1, 2, and 3 in Zamfara State. Specifically, CFC yielded more substantial enhancements in retention for students in Experimental Group 1 (taught by TBCK-CFC) and Experimental Group 3 (taught by TPCK-CFC). Conversely, Experimental Group 2 (TPK-CFC) exhibited no significant improvement in retention. This finding is consistent with the observations of Abdullahi (2021) and Ibrahim (2012), regarding the limited effect of professional development on teachers with Pedagogical Knowledge-only. These results indicated the important role of teachers' knowledge bases in influencing student retention. Abdullahi (2021) described teachers with only Pedagogical Knowledge-only as out-of-field biology teachers. He attributed their ineffectiveness in improving students' retention to their lack of deep subject knowledge, which hampers their instructional ability to resolve students' conceptual difficulties.

The analyses of hypotheses three and four revealed a significant gender difference in academic performance and retention among SS 2 students in Zamfara State across Experimental Groups 1, 2, and 3. Notably, CFC consistently proved effective, for student participants in the Experimental Groups 1 and 3, where gender disparities are minimal. Conversely, noticeable gender-related disparity emerged in Group 2. These findings stressed on the advantages of Biological Content Knowledge and balanced Pedagogical Content Knowledge in mitigating gender discrepancies in biology classroom. These findings are in agreement with Shulman's philosophical perspective, as reported by Abdullahi (2021), Streiling et al. (2021), and Omosebi (2021). They reported that having a combination of subject matter knowledge with effective pedagogy, promotes inclusivity and reduces gender related differences in science classroom. The findings of the present study are consistent with Anoh and Oyekanmi (2021) and Abza et al. (2022), who highlighted the importance of these factors in achieving gender equitable learning outcomes in biology. Similarly, Ibrahim (2012) found that teachers with Pedagogical Content Knowledge exposed to professional and mentoring support significantly improved performance and retention in both male and female students compared to those without such exposure. Therefore, in contrast to previous assumptions of Njoku and Nwagbo (2020) regarding biology's gender neutrality, this present study has proven that effective teaching strategies and subject-specific expertise are instrumental in fostering gender equitable learning outcomes.

## 7. Conclusion

The findings indicated the significant effectiveness of CFC, particularly for teachers with Pedagogical Content Knowledge (TPCK-CFC) and Biological Content Knowledge (TBCK-CFC). It showed less efficacy for teachers with Pedagogical Knowledge-only (TPK-CFC). Significant effects were observed in academic performance and retention in difficult biology topics among SS 2 students taught by TPCK-CFC and



TBCK-CFC. Gender differences were evident, with CFC being most effective for both male and female students taught by TPCK-CFC and TBCK-CFC. These findings revealed CFC as an effective professional development model, addressing teacher knowledge gaps and improving students' performance and retention in challenging biology topics. CFC also promoted gender equitable learning outcomes in biology.

## 8. Recommendations

Based on the findings of the study the following recommendations were made:

To curtail persistence poor performance in biology subject, Zamfara State Ministry of Education should adopt CFC as a PD model for improving biology teachers' content and pedagogical skills in teaching challenging topics in the subject.

School authorities in Zamfara State should stop assigning teachers with Pedagogical Knowledge-only to teach biology. Instead, they should prioritize recruiting qualified biology teachers to fill vacancies.

Teachers with Biological Knowledge-only should be encouraged and supported to acquire Postgraduate Diploma in Education to enrich their teaching capabilities through exposure to essential pedagogical skills.

## Author contributions

Akilu Isma'il<sup>1\*</sup> conducted the primary research and analysed the data. Dr. Suleiman Sa'adu Matazu<sup>2</sup> (Associate Professor) served as the supervisor, providing guidance throughout the research process. Both authors contributed to the writing and editing of the manuscript.

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## Declarations

The authors declared that they have no competing interests related to this article.

## Data availability and sharing policy

Applicable.

## Author notes

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