

 Research Article

Implementing Cooperative Learning for Sustainable STEM Education in Nigeria: Preservice Science Teachers' Knowledge and Beliefs

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Abstract

The study investigated preservice science teachers' (PST) knowledge and beliefs about the implementation of cooperative learning for sustainable science, technology, engineering, and mathematics (STEM) education in Nigeria given that evidence shows that several Nigerian teachers are still unskilled in 21st-century pedagogies. The study sought to determine PSTs' competencies for implementing cooperative learning in science classrooms, as informed by their knowledge and beliefs about the effectiveness of applying cooperative learning to teach science concepts. Four research questions guided the study. The design of the study is a descriptive survey involving the collection of quantitative data via questionnaires. This research design is appropriate for the present study as it sought to determine the knowledge and beliefs PSTs have about cooperative learning (CL). The study sample was drawn from all the PSTs in the federal tertiary institution (Nnamdi Azikiwe University, Awka) in Anambra State, Nigeria using the convenience sampling technique. The data for this study were collected electronically using an adapted version of Bouas (1993). The scale's reliability was determined using the Cronbach alpha technique ($\alpha=.73$). Percentage, weighted mean, and standard deviation, and one sample t-test were used to analyse the data collected in this study. The study's findings showed that PSTs in Nigeria were both knowledgeable and held positive beliefs about cooperative learning pedagogy. Based on the study's findings, implications for the study were discussed.

Keywords: 21st-Century Pedagogy, Cooperative Learning (CL), Preservice Science Teachers (PSTs), STEM Education

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1. INTRODUCTION

Rethinking 21st-century pedagogy for sustainable STEM education is fundamental to identifying the skills required by learners to survive amidst the present global realities of the 21st-century. According to Keane et al. (2016), these skills include collaboration, creativity, and critical thinking skills among others, and are currently emphasized at all levels of education. The emphasis is also laid at the international level by international organisations such as the Organisation for Economic Cooperation and Development (OECD, 2018) and the United Nations Educational, Scientific and Cultural Organisation (UNESCO, 2016), for the development of individuals with the necessary competencies for solving complex global problems. For this reason, there is a need for the implementation of 21st-century pedagogies that would equip students with the needed aforementioned skills for survival (Geletu, 2022).

Any pedagogy that emphasises and promotes the acquisition and development of these skills can be considered to be 21st-century pedagogy, and according to Møgelvang and Nyléhn (2023), one of such pedagogies is cooperative learning. Cooperative learning (CL) can be considered to be a 21st-century pedagogy because it fulfils the demands of multicultural societies that require the appreciation of the beauty in diversity and equips students with the necessary competencies needed to thrive in the 21st-century world

that is interdependent and heterogeneous (Hossain & Ahmad, 2013). CL is a suitable 21st-century pedagogy for attaining the aforementioned skills because of its potential for developing intercultural and social competencies in learners. Research evidence has established CL to be an effective means of improving students' learning outcomes (Abramczyk & Jurkowski, 2020; Buchs et al., 2017). However, teachers in Nigeria appear to be unskilled in the use of CL as well as other 21st-century pedagogies (Unachukwu & Nwosu, 2014) to promote students' development and learning outcomes. Therefore, it is the objective of this study to investigate preservice science teachers' (PSTs) knowledge and beliefs about CL. This objective is necessary because PSTs are being groomed in different teacher education programmes to replace the in-service teachers in the long run.

1.1. Literature Review

1.1.1. Preservice Science Teachers

PSTs refer to undergraduate students who are currently undertaking teacher education programmes in a specific scientific discipline in teacher education institutions, such as colleges of education or education faculties in universities, to become qualified teachers in that field (Nwune et al., 2023). The researchers posited that PSTs earn a National Certificate in Education (NCE) or a Bachelor of Science in Education (BSc. Ed) upon completion of their studies. These teacher education institutions facilitate the development of students into proficient teachers by bridging the divide between theoretical knowledge and practical application. The primary objective of PSTs' training programmes is to provide them with essential theoretical and practical knowledge and competence for the teaching profession. Similarly, these programmes aim to equip PSTs with the necessary skills to maximise their productivity as science teachers and prepare them for fostering the growth of their students and society as a whole, using 21st-century pedagogies such as cooperative learning.

1.1.2. Cooperative Learning

Cooperative learning is a pedagogical approach supported by research evidence, which entails organising students for interaction and equipping them to cooperate and work together in small groups to enhance each other's learning processes (Abramczyk & Jurkowski, 2020; Buchs et al., 2017). Topping et al. (2017) argue that CL involves a distinct approach to classroom dynamics compared to traditional methods. In CL, teachers play a crucial role in organising students' interactions and ensuring they are well-prepared to collaborate. CL, as a learner-centred teaching method, promotes collaboration instead of competition, often found in traditional teacher-centred approaches. Unfortunately, the current educational system tends to prioritise individualism, further supporting these traditional pedagogies (Moges, 2019; Singh & Agrawal, 2016). Furthermore, when compared to traditional teaching methods that hinder the implementation of personalised learning for students in diverse environments, CL offers customised instruction for students according to their learning styles (Smets & Struyven, 2020; Tomlinson, 2017). Moreover, CL, being a learner-centred approach, shifts a larger portion of teaching responsibilities from teachers to the learners (Buchs et al., 2017). This suggests a transition of teachers' responsibilities from being custodians of learning to facilitators of the learning process.

Teachers can utilise several techniques to implement CL in typical classrooms. The techniques proposed by Abramczyk and Jurkowski (2020) consist of a team tournament, where rewards are given to each group member based on their performance improvement, and a jigsaw approach, where group members rely on each other to acquire knowledge about the learning content and provide instruction based on their expertise in a specific topic. Additional techniques for implementing CL encompass cooperative instructional modelling, cooperative peer review frameworks, group contracts, process-oriented guided inquiry, rotating roles, and think-pair-share, among various others (Møgelvang & Nyléhn, 2023). Despite their apparent differences, these techniques maintain consistent basic principles.

CL is guided by five basic principles. The principles encompassed in this framework consist of students' positive interdependence, individual and group accountability, promotive interaction, interpersonal and small-group abilities, and group processing (Ghaith, 2018; Gillies, 2023; Ibrahim & Ibrahim, 2017; Lang et al., 2016). The principle of positive interdependence among students encourages

cooperation as well as teamwork by giving specific tasks to each member, so motivating them to work together and achieve success. The primary objective of this principle, as stated by Bada and Jita (2022), is to foster efficient collaboration among students within a CL group. The principle of individual and group accountability allows students to demonstrate responsibility for prescribed duties, both individually and as a group. The assessment of accountability can be ascertained by the utilisation of rubrics, teacher observations, and peer evaluation (Bada & Jita, 2022). The promotive interaction principle advocates for CL group members to engage in discussions and reflections on a topic, intending to critique and reconstruct diverse members' thoughts and perspectives into a unified whole. The interpersonal and small group social skills facilitate the integration of students in a CL group and enhance their CL experiences. This skill enhances the unity and collective motivation among members of a group. The group processing principle facilitates the evaluation of the achievements of the groups in attaining the objectives established by the teacher. Without a comprehensive grasp and implementation of the aforementioned principles, CL cannot be judged successful.

The predetermined objectives established by the classroom teacher before the initiation of CL dictate the length of time for each CL group (Møgelvang & Nyléhn, 2023). The researchers observed that when classroom teachers want students to acquire certain information, they organise CL groups that can run from a single class period to several weeks or even months. This method of grouping is regarded as formal. Alternatively, when the teacher wants students to actively participate in classes, they frequently organise CL groups that can last anywhere from a few minutes to an entire class period. This method of grouping is seen as informal. To ensure the successful application of CL, it is recommended that the groups should be composed of 3-5 persons (Kagan, 2021). Geletu (2022) suggested four methods for teachers to organise students in CL groups: arbitrary grouping, ability-based grouping, mixed grouping, and compatibility-based grouping. The aforementioned methods of grouping can be done either homogeneously or heterogeneously. Unlike the homogeneous grouping that integrates students with the same characteristics in a CL group, the heterogeneous grouping involves the integration of students with diverse characteristics such as gender, academic ability, age, and religion, among other criteria, to eradicate initial misconceptions and prejudices among students (Igboanugo, 2013). The heterogeneous grouping is the most often supported approach in CL literature considering its enormous prospects.

CL, when well executed, can bring advantages to students across all educational levels. The advantages encompass various aspects of students' academic performance, such as personalised instruction and exercises that are tailored to individual student's characteristics, fostering knowledge development and retention, enhancing motivation for learning, addressing cognitive needs, facilitating effortless learning, fostering self-confidence, and promoting active engagement in classroom activities (Bada & Jita, 2022). In addition to the academic advantages, implementing CL can enhance students' social and communication skills, foster inclusivity, and cultivate an appreciation for diversity. This is achieved by encouraging students to accommodate and value their group members from diverse backgrounds (Geletu, 2022). The aforementioned advantage of CL aligns with the United Nations' sustainable development goal number four, which aims to guarantee inclusive and equitable quality education for all students, regardless of divisive circumstances (UN, 2015). However, if CL is not applied successfully, Gillies (2016) and Bada and Jita (2022) argue that it may lead to conflict among students as they struggle with the requirements of the assigned group activity and the procedures necessary to complete it. Therefore, there is a need for teachers to accelerate their competencies in effectively applying the principles of CL during classroom teaching.

1.1.3. Challenges in Implementing Cooperative Learning

Despite research evidence demonstrating the effectiveness of CL in equipping individuals with the necessary skills for success in the 21st century, classroom teachers still struggle with implementing this teaching method in their classrooms (Abramczyk & Jurkowski, 2020; Buchs et al., 2017; Geletu, 2022; Topping et al., 2017). Teachers face several challenges while implementing CL, as highlighted in the literature. These challenges include the shift in teachers' responsibilities from being in control of the classroom to managing groups and facilitating students' learning. Transitioning from the role of a controller in traditional classrooms to the role of a facilitator in a CL context may provide challenges for these teachers. Another challenge is the necessity for a significant investment of time, effort, and resources. CL, which is a pedagogy that focuses on the learner, necessitates careful preparation to reduce disadvantages

and maximise advantages. Therefore, the process of designing and executing this teaching method requires a significant amount of time, effort, and resources, which may discourage teachers from using it in their classrooms. Another obstacle to implementing this teaching method is the disciplinary issues that arise when students work in groups and the evaluation of their performance. Teachers often face this difficulty when they haphazardly create and implement CL with group tasks that lack challenge and motivation.

Additional challenges as highlighted by Bada and Jita (2022), encompass the disparities in mental and cognitive capacities among students within CL groups, as well as grievances and animosity towards students who are less assertive or fail to meet the group's established criteria. This most often leads to the development of low self-esteem and withdrawal from group activities among these students, ultimately impacting their learning outcomes. Additionally, the researchers have observed that the creation of an unfavourable classroom climate leads to unhealthy competitiveness, which in turn poses problems for classroom teachers during the implementation of CL. Anderson (2019) found that the examination structure in school systems, which prioritises knowledge, presents a difficulty for CL because it focuses on developing relevant skills for thriving in the modern world.

A further challenge to implementing CL is the lack of competence among classroom teachers in this instructional approach (Abramczyk & Jurkowski, 2020; Bada & Jita, 2022; Girma & Abraham, 2019;). The researchers state that classroom teachers' competencies in CL encompass their knowledge of various implementation strategies, the fundamental principles of implementation, and their beliefs regarding its effectiveness in improving students' learning outcomes. According to the researchers, teachers' perceptions regarding the usefulness of CL vary among various demographics. The researchers hypothesised that teachers perceived the pedagogy to be more effective for older students and those with high or medium performance levels, compared to younger children and those with lower performance levels, as well as special needs students. The competencies of teachers in CL play a crucial role in the adoption and implementation of this teaching method in the classroom. A competent teacher, who possesses knowledge of cooperative learning methods and principles and holds positive beliefs about its effectiveness, can effectively address the challenges mentioned earlier by creating a favourable classroom environment that is conducive to the successful implementation of the pedagogy (Bada & Jita, 2022).

To effectively implement CL in classrooms and reap its benefits, it is crucial to assess the competencies (knowledge and beliefs) of teachers regarding this pedagogy. Research (Abramczyk & Jurkowski, 2020; De Hei et al., 2015; Er & AtaÇ, 2014) revealed that teachers possessed an in-depth knowledge of CL and held favourable beliefs regarding its effectiveness in enhancing students' academic and social learning outcomes. While the aforementioned reviewed studies on the subject of interest used in-service teachers as their respondents, the current study focused on analysing PSTs who were still in training, specifically regarding their knowledge and beliefs about CL. The decision to include PSTs in this study is based on the significance of science and technology in the 21st century and the necessity of fostering collaboration in scientific endeavours among upcoming science teachers.

Science disciplines frequently facilitate collaborative work, either as a deliberate teaching strategy or as a result of limited resources. Therefore, comprehending CL in this particular context is crucial and may vary from other contexts. One further justification for including PSTs in this study is their growing preparation and support to become future teachers who will replace current teachers in primary and secondary schools. Therefore, a lack of expertise and a pessimistic mindset towards CL would be evident in their teaching methods, which may not be sufficiently effective for teaching science in schools. Moreover, the researcher observed a paucity of literature in the Nigerian context on the subject of interest, thus necessitating the conduct of the present study to determine the following;

1. Are preservice science teachers knowledgeable about cooperative learning?
2. What are the beliefs of preservice science teachers about cooperative learning?
3. Is gender significant in preservice science teachers' knowledge about cooperative learning?
4. Is gender significant in preservice science teachers' beliefs about cooperative learning?.

2. METHODS

2.1. Research Design

The study utilised a descriptive survey research design. Nworgu (2015) defines this research approach as a thorough and meticulous analysis of a situation to determine its nature and characteristics. This research design is appropriate for the present study as it sought to determine the knowledge and beliefs PSTs have about CL.

2.2. Participants

Three hundred and twenty-four (324) students from the Science Education and Technology and Vocational Education Departments of Nnamdi Azikiwe University Awka participated in the study.

Table 1. Participants' Information

Respondents (N=324)	Number of Participants
Gender	
Male	75
Female	249
Department	
Science Education (SED)	303
Technical & Vocational Education (TVE)	21
Year of Study	
100 Level	59
200 Level	10
300 Level	32
400 Level	223
Age	
16-20 years	83
21-25 years	226
26-30 years	15

2.3. Research Instruments

The questionnaire used to collect data for the study was adapted from Bouas (1993) and contained three sections – A, B, & C. Section A comprises demographic variables, section B comprises 15 item statements about PSTs' knowledge of CL, while Section C on the other hand includes 10 item statements for PSTs' beliefs about CL. The instrument was subjected to Cronbach Alpha reliability test which yielded a reliability index of 0.73 indicating that the instrument is reliable. After the reliability test, item 2 in section B (In cooperative learning, students are responsible for their learning), and item 3 (I think students of the same ability should be grouped together in every task), in section C were removed because the students did not fully understand the item statements as indicated by the item output coefficients. The respondents rated the items on a five-point scale of Strongly agree (SA) to strongly disagree (SD).

2.4. Data Collection and Analysis

The data for this study was electronically collected using Kobotoolbox. The link to the electronic questionnaire was forwarded to the PSTs' social media (WhatsApp) platforms. After getting their consent to participate in the study, the respondents were requested to access the questionnaire using the link and make responses as applicable to them. The collected data were analyzed using percentages for research question 1; weighted mean and standard deviation for research question 2, while one sample t-test was used to answer research questions 3 and 4.

3. RESULTS

3.1. Research Question 1: Are Preservice Science Teachers Knowledgeable About Cooperative Learning?

Figure 1 shows that out of the 324 respondents, 93% (301 PSTs) indicated that they were knowledgeable about CL comprising the different techniques and principles of implementation. On the other hand, 7% (23 PSTs) indicated that they were not knowledgeable about CL. Based on the result, the majority of PSTs within the study context can be considered to be knowledgeable about CL.

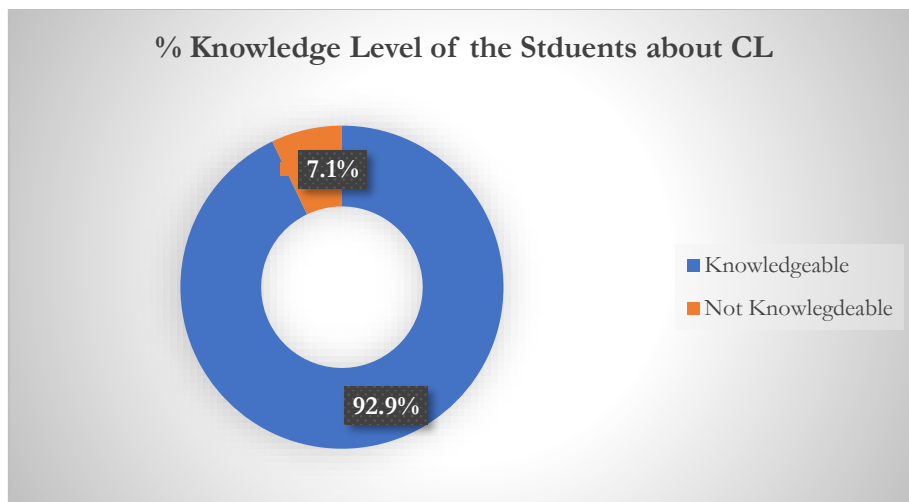


Figure 1. Percentage of PST's Knowledge About CL

3.2. Research Question 2: What are the Beliefs of Preservice Science Teachers About Cooperative Learning?

Mean and standard deviation of students' beliefs about cooperative learning is presented in Table 2.

Table 2. Mean and Standard Deviation of Students' Beliefs About CL

S/N	Item	N	Mean	SD	Remarks
1	I think I will use cooperative learning as a teaching strategy more frequently	324	4.54	0.67	Positive
2	When I am involved as a student in cooperative learning activities, I feel closer to my classmates as a result of the group work	324	3.99	1.00	Negative
3	When working in a group, I think I put in more effort to perform well on assignments because I feel obligated to other group members to do well	324	4.07	0.73	Negative
4	I think it is easy to trust other group members to carry out their share of the group workload	324	4.07	0.72	Negative
5	I think group learning helps students learn to be tolerant and considerate of the opinions of other group members	324	4.46	0.64	Positive
6	I find it easy to be involved in learning when working in a small group	324	4.31	0.77	Positive
7	I think I will use cooperative learning as a teaching strategy more frequently	324	3.63	0.98	Negative
8	When I am involved as a student in cooperative learning activities, I feel closer to my classmates as a result of the group work	324	4.42	0.66	Positive
9	When working in a group, I think I put in more effort to perform well on assignments because I feel obligated to other group members to do well	324	4.24	0.85	Positive
Total		324	4.18	0.78	

Note: N = 324; Decision: weighted average = 4.18

Using the weighted average (4.18 ± 0.78) the findings show that most respondents appear to believe that CL reduces the workload for all the group members. Also, they believe that CL brings them closer to their classmates as they work in small groups. Again, the students believe that working in groups makes them perform well in their assigned tasks because they feel obligated to other group members to do well. Similarly, the students have a positive belief that CL enables them to be tolerant and considerate of others. Finally, the students believe that CL makes it easy for them to work together with others. On the other hand, the majority of the participants had negative beliefs that CL reduces their competitiveness in learning. Also, the students had negative beliefs regarding their competence to plan lessons in their subjects' majors using CL. Again, they had negative beliefs about the frequent use of CL in the future. Finally, the students did not believe that CL could help them trust other group members to complete their tasks. The average standard deviation (0.78) score which is far from the average mean, indicates that the student's responses were heterogeneously distributed.

3.3. Research Question 3: Is Gender Significant in Preservice Science Teachers' Knowledge About Cooperative Learning?

Table 3 shows that gender is significant in PSTs' knowledge about CL. This is because the P-value is less than the critical value ($P \leq 0.05$).

Table 3. T-Test of Significance of Gender Influence on PSTs' Knowledge About CL

	t	df.	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Gender	52.589	323	0	1.228	1.18	1.27
Knowledge	112.661	323	0	67.468	66.29	68.65

3.4. Research Question 4: Is gender Significant in Preservice Science Teachers' Beliefs About Cooperative Learning?

Table 4 shows that gender is significant in PSTs' beliefs about CL. This is because the P-value is less than the critical value ($P \leq 0.05$).

Table 4. T-Test of Significance of Gender Influence on PSTs' Beliefs About CL

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Gender	52.589	323	0	1.2284	1.1824	1.2743
Beliefs	171.45	323	0	37.735	37.302	38.168

4. DISCUSSION

The study investigated PSTs' knowledge and beliefs about cooperative learning in Nigeria. The findings of the study indicate that the majority of PSTs are knowledgeable about CL, its diverse techniques, and principles of implementation. This finding could be because this teaching method is used to teach them diverse scientific concepts in their teacher preparatory programmes, and has thus availed them the opportunity to be conversant with it. Similarly, the findings of the study show that the majority of PSTs had positive beliefs about CL's effectiveness in reducing academic workload, motivating them to learn, enhancing their interpersonal relationships and social skills, and promoting their sense of inclusivity. This finding could be because of the benefits they have derived from this teaching method over time in their teacher education programmes. These findings are consistent with Abramczyk and Jurkowski (2020), De Hei et al., (2015), and Er and AtaÇ, (2014) who posited from the findings of their studies that teachers were

well-informed about CL and had positive beliefs about the effectiveness of CL in enhancing their students' academic and social learning outcomes. In the Nigerian context, the findings of this study contradict the assertion made by Unachukwu and Nwosu (2014) that Nigerian teachers lacked the necessary skills for implementing 21st-century pedagogies like CL. According to the findings, PSTs' knowledge and positive beliefs about CL is an indication that their teachers, and by extension, Nigerian teachers are implementing CL and as well as other 21st-century pedagogies in their classrooms. However, the contradiction of these findings with Unachukwu and Nwosu's (2014) assertion could be a result of the time lapse that has availed Nigerian teachers the opportunity to acquire 21st-century pedagogical skills and compete with their counterparts in other parts of the world. Regarding the significance of gender on PSTs' knowledge and beliefs about CL, the findings of the present study show that gender is a significant factor. This finding could be a result of the learning preferences of the respondents based on gender. The finding of the study is in line with Er & AtaÇ (2014) who posited that male students preferred individualistic learning to cooperative learning, unlike their female counterparts. According to de la Iglesia, Stover, and Fernández Liporace (2014), females are more likely to enjoy and work with more social networks than males who work alone or at most, search only for a few people. On the other hand, the finding of this study runs contrary to De Hei et al., (2015) who stated that irrespective of gender disparities, students had similar knowledge and beliefs about CL.

5. IMPLICATION OF FINDINGS

Although a majority of PSTs investigated in the study context perceived themselves as knowledgeable about CL, its techniques and principles of implementation, and had positive beliefs regarding its effectiveness in enhancing students' learning outcomes, there is still some work to be done in teacher education programmes to help the PSTs in the minority to gain sufficient expertise and develop positive beliefs about CL. The aforementioned can be achieved by laying more emphasis on CL for teaching scientific concepts in the various teacher education programmes. Also, policymakers and curriculum planners of teacher education programmes should lay more emphasis on the in-depth utilisation of the CL pedagogy. Similarly, training, workshops, and orientation exercises can be provided for PSTs on the procedures and benefits of implementation of CL and other 21st-century pedagogies. Achieving the aforementioned is necessary to sufficiently prepare PSTs to take over from in-service teachers at the primary and secondary school levels who are unskilled in the deployment of 21st-century pedagogies as shown by research evidence.

6. CONCLUSION

From the findings of the study, it was inferred that the investigated PSTs possessed the knowledge and held positive beliefs about CL, a 21st-century pedagogy needed for sustainable STEM education in Nigeria. Also, the findings inferred that these knowledge and beliefs varied according to PSTs' gender. Thus, it is apparent that PSTs are sufficiently prepared in the different teacher education programmes in Nigeria to effectively teach science concepts at the primary and secondary levels of education as they graduate and become future science teachers. These PSTs can be described as the hope for sustainable STEM education in Nigeria amidst the present localised and global challenges of the 21st-century which Nigeria alongside other nations of the world is currently facing. PSTs and in-service science teachers leverage these 21st-century pedagogies to inculcate in students at all levels of education, the necessary 21st-century skills for solving complex global problems and attaining all-round sustainable development.

7. LIMITATIONS OF THE STUDY

Every research endeavour is usually bedeviled by some challenges which try to limit the study and its findings. The present study is no exception. The findings of the present study were limited due to the limited recent and relevant literature found on the subject of knowledge and beliefs about cooperative learning both within and outside the Nigerian context. Another limitation of the study's findings is the small sample size (respondents) used for the study and the convenience sampling technique used to obtain them. This sample may not be representative enough to make generalisations.

8. SUGGESTIONS FOR FURTHER STUDY

Future researchers may decide to conduct the same study using much larger and wider study participants across the country (Nigeria). Secondly, these researchers may decide to explore the relationship between PSTs' knowledge and beliefs about CL and their propensity to use it in the future to teach science concepts to their students when they become in-service teachers in primary and secondary schools. Also, future research can explore how 21st-century pedagogies can be used to address the challenges of the 21st-century.

Data Availability Statement. All data can be obtained from the corresponding author.

Conflicts of Interest. The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

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