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IMPROVING TEACHING AND LEARNING OF ORGANIC CHEMISTRY IN SENIOR HIGH SCHOOLS USING COLLABORATIVE APPROACHES

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ABSTRACT

This study investigated Chemistry students' performance and retention (knowledge and understanding, knowledge and application, perception and attitude) in Organic Chemistry in three Senior High Schools (SHSs) within Tamale Metropolis in Ghana. Collaborative learning models were employed as intervention strategies. Quasi-experimental design was adopted for the study. The target population for the study was third year SHS Chemistry students. Two intact classes were used as control and experimental groups in each school. The research instruments were self-constructed Organic Chemistry Achievement Test (OCAT) and Students' Attitude and Perception Questionnaire (SAPQ). The Organic Chemistry Achievement Test data was analysed using t-test statistics whilst Students' Attitude and Perception Questionnaire data was analysed using descriptive statistics. The study revealed a 34.04% improvement in post-test mean scores on both knowledge and understanding, and knowledge and application due to the intervention. The study again revealed a significant improvement of (20%) in students' perceptions and attitudes towards Organic Chemistry due to the intervention. A statistically significant improvement of 25% in confidence level among students, towards Organic Chemistry, was recorded. Collaborative teaching and learning approaches were judged effective for ameliorating SHS learners, academic achievement and knowledge retention in Organic Chemistry concepts and were recommended for teaching and learning at SHS.

Keywords: collaborative learning, cooperative learning, organic Chemistry, group discussions, teaching strategies

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INTRODUCTION

Organic Chemistry is the study of the structures, characterisation, composition, reactions (and their mechanisms), and preparation of carbon-containing compounds. Most of the organic compounds contain carbon and hydrogen only, referred to as hydrocarbons. The hydrocarbons may also bond with some atoms such as fluorine, oxygen, nitrogen, chlorine, bromine, phosphorus, silicon, and Sulphur among others to form heteroatoms that are useful in the chemical space (Kais Abood, 2020). Organic Chemistry constitutes an important part of knowledge domain in our daily lives (Cooper et al., 2019). Its applications are diverse and crucial in science. These include food, paper, ink, rubber, soap, perfumes, medicines, pesticides, weedicides, petrochemicals, paint, plastics, textiles, and pomades among others. These applications are absolutely necessary to humans and animals for proper living (Book, 2017; Cooper et al., 2019; O'Dwyer & Childs, 2017).

It must however be noted that chemistry involve the study of the composition of matter and its interactions within the environment. It must also be realized that hydrocarbons which are the basis for organic chemistry can be found in most systems in the environment hence the need for its effective teaching and learning. Understanding why students perform poorly whilst others choose to ignore questions in organic Chemistry as they do in West African Senior Certificate Examination (WASSCE) is something that educators would like to find out to be able to create relevant learning opportunities.

The evidence is replete and not in any way contradictory that, there is academic underachievement in organic chemistry among SHS students in the sciences in Ghana. The yearly results (2011-2021), being published by the West African Examination Council (WAEC) and the annual chief examiners' report clearly indicate that there is academic underachievement in organic chemistry both in the elective chemistry and in the core integrated science (K. R. Adu-Gyamfi et al., 2013; Ofosu Amaah, 2019). According to Adu-Gyamfi & Asaki (2022), West African Senior Certificate Examination (WASSCE) results on chemistry for the past years had indicated that students have consistently performed below average. The annual report by the chief examiner (WASSCE-SC, 2019) has categorically revealed that the organic chemistry question in the essay type questions, was always neglected by candidates and few candidates who attempted it answered it unsatisfactorily. These questions always appeared unpopular among candidates. Candidates viewed these questions as very difficult and hence their neglect. Between the years (1993 – 2021) questions on organic compounds appear in the West African Senior Certificate Examination (WASSCE) which indicates the importance of such concepts to SHS chemistry learners. It has therefore become imperative for chemistry students to have a strong grasp of the concepts in organic chemistry. Similar revelations are made in Nigeria concerning poor academic achievement in the sciences especially in chemistry among Senior High School students (Ezike, 2018; Ojukwu, 2016). In Tanzania similar concerns were raised in the research findings of some studies (Maganga, 2016; Uk, 2014.). Oumaichrispine, Odawa & Mairos, (2011) in Kenya revealed similar trend in the abysmal performance in chemistry.

Academic achievement in this aspect of the sciences is a function of many variables like teacher qualification, teacher experience, teacher professionalism, students' attitude towards organic chemistry, students' future ambitions, and ultimately the methods and strategies of delivery in teaching and learning of hydrocarbons, organic chemistry (Dahiru Yusuf, 2014; (Dorsah et al., 2022). Some teachers are not impressive in their delivery, some teachers make students passive participants in the teaching and learning processes, some teachers do not upgrade themselves to the modern and current methods of teaching and learning, while some students are lackadaisical towards their own learning (Agbaje & Alake, 2014; Asikhia, 2019; Brown et al., 2015; Musengimana et al., 2021). Whatever the attitudes of students and teachers towards Organic chemistry are, coupled with the methods of teaching and learning, it has become necessary to develop teaching strategies that would employ effective methods to influence understanding and as well ameliorate best academic, social and psychological gains of learners in Organic Chemistry (Dorsah et al., 2022).

Collaborative learning is a terminology that houses several approaches and strategies to teaching in education. It provides the platform for an intellectual connection of students, or students and their teachers. In these approaches of collaboration, students are put in groups and monitored by their teacher(s) to work towards gaining an understanding of a problem or inventing new products or concepts and innovations (Lombardi, 2018).

Collaborative activities for learning may differ widely in their application and administration, but the major focus should be student-centered. Students must be allowed and engaged to explore the course materials to arrive at an intellectual understanding and agreement, but not only the explication of the learning materials to the learners (K. Adu-Gyamfi, 2022; Sibomana et al., 2020). With the adoption and application of collaborative learning approaches would see a significant shift from the teacher-centered environment in the chemistry classroom to that of a student-centered environment. Teachers in the collaborative environment would merge the lecturing and note-taking approach with guided students' discussions (Serwaa-Ampaafo, 2017; Sukmawati, 2020). Chemistry teachers in a collaborative chemistry classroom would consider themselves as facilitators and coaches and not brain banks to transmit knowledge (Dahiru Yusuf, 2014).

The study investigated the application of collaborative teaching and learning environment as an intervention for improving Senior High School students' performance and retention on concepts as well as the perceptions and attitudes in organic chemistry. The objectives included.

- assess SHS students' learning outcomes on knowledge and understanding, in Organic Chemistry concepts when the students are exposed to collaborative strategies.
- assess SHS students' learning outcomes on knowledge and application of concepts in Organic Chemistry when they are exposed to collaborative strategies.
- assess the perceptions and attitudes of SHS students towards organic chemistry when they are exposed to collaborative strategies.

The study intended to encourage chemistry teachers and students to adopt or adapt alternative and unorthodox teaching and learning strategies such as collaborative teaching and learning that would expose science students to improve upon their performances and retention of concepts learnt in Organic Chemistry as well as their perceptions and attitudes towards organic chemistry. The study was also intended to introduce science teachers to alternative classroom teaching and learning strategies that would help them improve on their classroom practices.

METHODOLOGIES

Theoretical Foundation

Collaborative learning environment is a learning theory that draws its stand and relevance from the Vygotsky's theory of "Zone of Proximal Development". This theory revealed that, learners rely on one another to find solutions to problems that they otherwise could not have been able to complete individually. Vygotsky's theory proposed that the cognitive development of children depends on how they interact with one another in the society. These interactions must be socio-culturally guided and mediated by parents, guardians, and facilitators. The theory provides the platform for children to work together in society. The modern explication of the theory in education to ameliorate students' performance gives birth to the collaborative methods of teaching and learning. Teachers and students, as well as students themselves work together in teaching and learning to find solutions to problems. The teacher assumes the facilitator role and places the learners in an active learning role where the learners collaborate to discover ideas and knowledge (Mcleod & Vygotsky, 2008)

Collaborative learning is the main channel through which the critical thinking skills and abilities of the learners are developed, and their ability to retain useful information is improved when they work together in groups (Byusa et al., 2021). Collaborative methods are sometimes referred to as peer-to-

peering learning. This has proven to be an effective method of learning that promotes deeper thinking in the chemistry classroom as learners brainstorm together (Dai et al., 2021; Iyamuremye et al., 2022; Romero, 2015). The use of collaborative strategies in the chemistry classroom has proven to have developed students' high-order thinking, their oral presentations, self-identity, and leadership roles. Students in the collaborative environment appeared to be more organized in their leadership positions (Abun, 2021; Barbara Leigh Smith et al., n.d.; Malan, 2021; Modesta Nkechinyere & Kelechi Ordu, 2018; Romero, 2015).

Cooperative Learning in the classroom

Cooperative learning as a collaborative learning environment where two students or more are assigned to work and find answers to a particular task (Dahiru Yusuf, 2014; Rocca et al., 2014). This approach is successful in small groupings where students are grouped based on mixed learning abilities and are subjected to different learning activities. Under the guidance of the facilitator, the learners share information to improve their understanding of the subject matter (Adams, 2013; Hanson, 2017). Students in this environment of learning make them responsible not only to their own learning in order to memorise it in terms of exams, but also responsible for creating conducive and helpful environment for holistic achievement (Yash & Singh, 2011a).

Cooperative learning among students in the classroom has been researched by several scholars. According to Yamarik et al. (2007), cooperative learning ensures effective student-facilitator and student-student interactions with the learning materials. This promotes students' interest and participation in the teaching and learning processes, and learners in the cooperative environment are bold in approaching questions and asking facilitators for clarification. Cooperative approach affects the performance of learners due to its ability to facilitate high-order thinking abilities of learners in the chemistry classroom (Tran et al., 2019; Yamarik et al., 2007). Majoka & Khan (2011) conducted a survey which studied the learning outcomes of cooperative learning comparatively the teacher-centered style of teaching. The study revealed the ability of cooperative environment to have improved the learners' skills and attitudes towards learning.

Cooperative learning beyond the classroom

Su et al. (2010) analysed several methods of teaching including cooperative method, and the findings of the studies showed that cooperative learning was an appropriate teaching method that could add value and transformation of lives in the world. Research on the Novel Laureates indicated that, even though individuals were awarded Novel Prizes, the work towards these achievements over the last 25 years has seen an increase from 41% to 75% cooperation work.

Cooperative learning helps individuals to perform task collectively towards achieving a desired goal (Hu et al., 2022; Yapici, 2016). The ability of people to work together, take responsibilities in their societies, and working for the interest of others and their communities depends on their exposer to cooperative learning environment. Such individuals are able to listen to others, question the conduct of others without provocation and performing other important roles assigned them in their societies (Lombardi, 2018).

To promote social interaction among learners, cooperative learning environment should be provided and guided by facilitators for desired outcomes. For an enhanced workplace environment, employers look out for appropriate social behaviour from employees (Cano-García & Rojas-Cazaluade, 2022). Cooperative learning would provide practical skills that learners need to thrive effectively in their societies and the workplaces (Yash & Singh, 2011c, 2011b). These approaches towards teaching and learning enables learner to become good leaders, make good decisions, communicate effectively, and

resolve or manage conflicts amicably (Yash & Singh, 2011). For psychological, social, and emotional development, students must be exposed to cooperative learning environment (Malan 2021).

Cooperative learning as a Motivational Set

Cooperative learning is a learning approach whose principles resonates with the concept of constructivist theory and Vygotsky,s theory of learning. It refutes the principles of the banking concept of education and promotes an environment that sees learners as active participants of the teaching and learning process (Bećirović et al., 2022; Fekri, 2016). Recent researches have confirmed that learning instructions that rely on collaborative approaches such as cooperative learning have realised huge impact on students' knowledge domains (Gillies & Boyle, 2010; Zarrabi, 2016). It inspires learners and boosts their confidence (Istianah et al., 2020).

Methods of Teaching Organic Chemistry

Several research conducted by scholars discovered the best and appropriate methods for teaching Organic Chemistry (Bretz & McClary, 2015; Nik Hassan et al., 2022). The act of teaching organic chemistry was investigated by researchers with the focus on identifying difficult concepts in organic chemistry and developed more students' engaging approaches to improve understanding (Anzovino & Lowery Bretz, 2015). Grove & Lowery Bretz (2012), as cited by (Sukmawati, 2020) implemented a spiral curriculum that ensured that organic chemistry concepts are taught repeatedly in the syllabus with increasing complexities as learners advance in their learning process. Concrete models for teaching molecular structures in organic chemistry was proposed by Stull et al. (2012), while Simple Explicit Animations method for teaching organic chemistry was used by Talib et al. (2012) all cited in (Sukmawati, 2020).

Further studies were conducted on methods of teaching organic chemistry with emphasis on methods that improved students' behaviour and attitude (Lopez et al., 2014). Students' cognitive knowledge of organic chemistry was assessed through students-monitored learning strategy (Horowitz et al., 2013; Lowery Bretz, n.d.).

In higher learning institutions such the universities, organic chemistry is considered as a core subject for chemistry and biochemistry students due to its importance in their future careers. Some surveys conducted in the universities and other institutions of higher learning revealed the continuous efforts by lecturers to improve students understanding of organic chemistry. Students are taught using methods that recognised relationship between the theories learnt in class and the experiences and applications in the real world (Bhattacharyya & Bodner, 2018; Bodner & Elmas, 2020). Further studies were conducted to find what was described as better and effective methods for teaching some concepts in organic chemistry that were considered by students as difficult. Organic nomenclature, chemical bonding, mechanism of organic reactions, chemical equations, and organic synthesis were some concepts considered as difficult. Higher thinking order of students' cognitive domain was employed for students to master concepts through problem-solving skills and organic synthesis skills. Innovative technologies were developed and employed to improve understanding of organic chemistry. These included the screen-capture method which uses Panopto programme developed by Dangelo (2014). The inverted teaching (IT) was also invented by Christiansen (Austin et al., n.d.; Austin, Gould, et al., 2018; Austin, Hammond, et al., 2018; Christiansen, 2014; Farouk & Fahmy, 2017)

The flipped classroom is a teaching and learning method that integrates several approaches to improve students' learning and classroom engagement through problem-solving activities given to students as homework. Organic chemistry concepts were taught using the flipped classroom approach under the guidance of their lecturers and the outcome was revealed to be positive (Cormier & Voisard, 2017; Luong, 2021; Oppong et al., 2022; Serhan et al., 2019; Tekane et al., 2020).

In recent times, researchers have focused on learning processes in organic chemistry that would build a framework of connections and intersections in teachers and students' reasoning. This sought to

explore and limit the perceptions of difficult concepts by chemistry teachers and students. In view of that, researchers have investigated and recommended the use of collaboration, cooperation, hands-on-activities, and problem-based learning to improve students' high order thinking abilities in concepts organic chemistry (Cooper et al., 2019; Deng & Flynn, n.d.; Sabitu et al., 2020).

Students' Misconceived Ideas, Attitudes, and Perceptions in Organic Chemistry

In Behavioural Psychology, attitudes are emotions, beliefs, and behaviours that students exhibit towards the study of Organic chemistry (Nartey & Hanson, 2021; Sibomana et al., 2020; Wasacz, 2010; Yousef Mai & Hamzah, n.d.). They usually result learners' experiences, and nurturing from the environment (Abun et al., 2021). They greatly influence the behavior of individuals. This can be enduring, but can also change through appropriate remediation (Abun, 2021; Omwirhiren et al., 2016). The attitudes portrayed by students induce the tendency to view the concepts as difficult or easy to work with. Thus, attitude is a determinant of students' success in organic chemistry (Cherry, 2019).

With respect to the constructivist learning theory, students' previous knowledge and perceptions about Organic Chemistry cannot be overlooked. Teachers and educators must look out for what students think about Organic Chemistry before embarking to teach it. Several studies revealed that, students' perceptions and conceptions towards Organic Chemistry are often different from those accepted by the scientific society. Their perceptions and conceptions are often scientifically incorrect and are referred to as misconceptions. Hence, students' misconceptions towards Organic chemistry are as a result of their misunderstanding of the concepts (Omwirhiren et al., 2016; Vishnumolakala et al., 2017). Organic chemistry concepts are important for our understanding of how chemical, biological, and physical aspects of the world functions. Students' inability to appreciate such importance of organic chemistry affected their zeal and passion towards learning it. This observation has been confirmed by West African Senior School Certificate Examination (WASSCE) annual chief examiners' reports. The chief examiners' report revealed the consistent neglect of questions on Organic Chemistry is worrying. The few candidates who attempted the questions could not answer the Organic Chemistry questions to satisfaction.

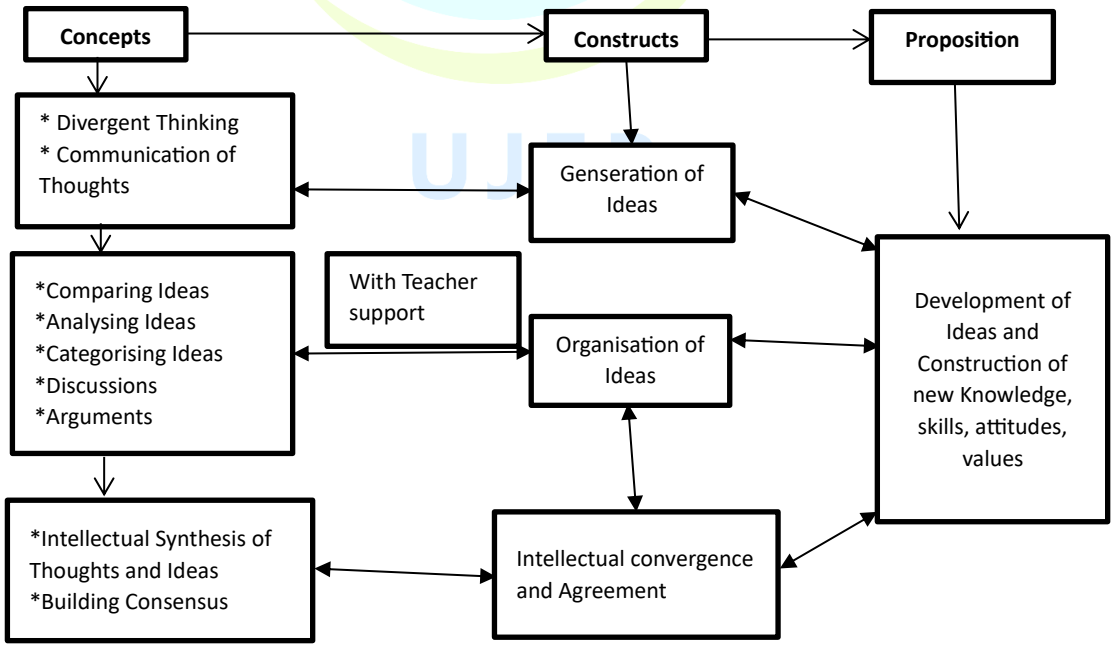

Figure 1. Model of Collaborative Learning Theory (MCLT).
Adapted Model of Collaborative Learning Theory (Magen-Nagar & Shonfeld, 2018)

Model of Collaborative Learning Theory (MCLT) enables students with divergent views on a particular concept in organic chemistry to communicate their thoughts among themselves. They then compare their ideas, analyse the ideas, and categorise them. The students then engage in deep group discussions to clarify arguments and doubts in other peoples' ideas. Through the support of the teacher during the group discussions and arguments, students are able to organise their ideas. The students further involve in an intellectual synthesis of thoughts and ideas through which a consensus is built. The learners would arrive at an important stage where an academic construct of understanding is achieved through intellectual convergence and agreements. Finally, propositions are developed and the learners are able to develop their ideas and construct new knowledge or understanding, skills, attitudes, and values of the organic chemistry concept being investigated.

Research Design

The mixed method approach was adopted for the research study. It enabled the research to obtain deeper knowledge and understanding of collaborative teaching and learning and its impact on students learning outcomes through statistics and numbers, perception, and attitudes. Quasi-experimental-control group design was selected for the research. This allowed for manipulation of the research independent variable without random assignments of participants to the various groups (White & Sabarwal, 2014). The study employed research instruments such as, organic chemistry achievement test (OCAT) and students' attitude and perception questionnaire, (SAPQ). These instruments were administered as pre-test to control and experimental groups. This was done to ensure the groups have similar strengths. An intervention using collaborative teaching and learning models on 5E model of inquiry-based science instruction (Bybee, 1997) (engagement, exploration, explanation, elaboration, and evaluation) was carried out on the experimental group. After five (5) weeks of intervention, post-test OCAT and SAPQ were administered to the groups to assess the effects of collaborative approaches on the SHS students' classroom achievements/performance, attitudes, and perceptions towards organic chemistry. This design is illustrated in Table 1.

Table 1: Non-randomised pre-test and post-test quasi-experimental design

Groups	Pre-test	Intervention	Post-test
Control	OCAT	Conventional method	OCAT
Experimental	OCAT	Collaborative approaches	OCAT
Control	SAPQ	Conventional method	SAPQ
Experimental	SAPQ	Collaborative approaches	SAPQ

Sample and Sampling Procedure

The study population included all science SHSs in Tamale Metropolis in the Northern Region, Ghana. Three science schools were selected by simple random sampling for the study. This provided equal opportunities for all the science schools in Tamale Metropolis, thereby eliminating issues of bias in the selection of the three schools. The schools were represented as School A, School B, and School C. Two intact classes in each of the schools were used constituting total sample size of 180 participants for the study. These included third year science students in the three schools. 99 of the students were males and 81 were females. The details are shown in Table 2.

Table 2: Sample distribution from three schools

School	Experimental group	Control group	Sub-total
A	35	30	65
B	18	22	40
C	40	35	75
Total	93	87	180

Research Instruments

The research used pre-test and post-test organic chemistry achievement test (OCAT) and students' attitude and perception questionnaire, (SAPQ). OCAT was used due to its high degree of internal consistency with minimal standard error of measurement. It is recommended for prognostic, diagnostic, formative, and summative assessments of students to determine the effects of a treatment over a period of time (Matthew, 2019; Salbiah Omar et al., 2016). SAPQ is the most appropriate research instrument that reveals the behaviour of students towards organic chemistry (Cano-og Moneva et al., 2021; ozan & Korkmaz, 2018). The instruments, OCAT and SAPQ were self-constructed.

The two set of instruments used were validated (face, content, and construct validity) by experts who are lecturers, with experience in science education in School of Science, Mathematics and Technology Education (SoSMTE), C. K. Tedam University of Technology and Applied Sciences (CKT-UTAS) and other collaborating schools. Reliability coefficient of the instruments was determined using Cronbach alpha statistics which gave alpha values of 0.81 and 0.87 respectively for organic chemistry achievement test (OCAT) and students' attitude and perception towards organic chemistry questionnaire (SAPQ). The reliability coefficients of 0.81 and 0.87 indicated a good reliability and that the instruments were consistent.

Data Collection and Analysis

The study complied with all research ethical considerations and practices during the study. The School of Science, Mathematics and Technology Education (SoSMTE), C. K. Tedam University of Technology and Applied Sciences (CKT-UTAS), provided ethical clearance letter and an introductory letter for data collection. The letters were used to obtain permission from the three participating schools. The students' consent and approval were sought before they were included in the sample size from the intact classes. SAPQ was administered first to both groups to gather information on the students' behaviour towards chemistry.

OCAT pre-test was also then administered to the groups to ascertain their strengths before intervention. An interactive collaborative teaching and learning approaches were then blended on the experimental group for a period of five weeks whilst the control group was left without any intervention treatment. The intervention lasted for a period of five weeks and OCAT post-test was administered to the groups. A post intervention students' attitude and perception questionnaires, (SAPQ) were administered to ascertain the changes in students' response after the intervention. The administration of the study instruments was concurrently conducted in schools A, B and C.

The data from the pre-test (OCAT and SAPQ) and post-test (OCAT and SAPQ) of the control group and the experimental group were accumulated and analysed quantitatively. The OCAT was analysed using t-test contained in SPSS, version 27. The SAPQ was also analysed using descriptive statistics (frequencies and percentages) contained in SPSS, version 27.

RESULTS

Table 3: T-test Analysis of OCAT (pre-test) for Experimental and Control Groups

Groups	N	X	Df	t-value	p-value
Experimental	93	43.63	178	1.52	0.07
Control	87	39.97			

P-value = 0.05 (Significant level)

A t-test analysis of organic chemistry achievement test OCAT showed a p-value of 0.07 from Table 3, The P-value is greater than p-value 0.05 (Significant level). This indicates that the difference in the groups

means scores were not statistically significant, and that the participants were of similar class ability or characteristics.

Table 4: T-test Analysis of OCAT (post-test) for Experimental and Control Groups

Groups	N	X	Df	t-value	p-value
Experimental	93	58.48	178	1.84	0.02
Control	87	40.77			

P-value =0.05 (Significant level)

The intervention for the experimental group using collaborative learning approaches (group discussions, peer-teaching, and student-centered hands-on activities) was conducted on the experimental groups for a period of five weeks and an OCAT post-test administered on both groups. From Table 4, the p-value of 0.02 was recorded which less than the p-value of 0.05 is indicating that there was a significant difference between the experimental and control groups. The experimental group taught using the collaborative learning activities and approaches performed significantly higher than the control group who were taught using non-collaborative approaches and activities such lecture method and teacher-centred demonstrations in class.

Table 5: Experimental and Control Groups Pre-intervention Responses to Attitude and Perception towards Organic Chemistry Questionnaire

Item	Responses				
	SA	A	D	SD	X
The most interesting aspect of chemistry is organic chemistry	15	24	94	46	1.91
I get terrified working with structures of organic compounds	115	55	10	0	3.24
I easily get confused with the IUPAC nomenclature of compounds	98	34	15	33	2.58
It is not applicable in our daily lives and not important to learn	71	88	10	11	2.50
I love to attend organic chemistry class to engage in discussions	22	13	20	125	3.73
Organic chemistry is necessary for my future career growth	50	35	86	9	1.87
I do not enjoy any lesson in organic chemistry	5	25	135	15	1.92
It is boring when I participate in organic chemistry lessons	119	24	17	20	3.16
I become stressful in class during organic chemistry lessons	119	12	22	27	3.07
It makes me restless in class	94	55	31	0	2.61
I have good feelings towards chemistry in general except organic chemistry concepts	105	61	14	0	3.24
I feel nervous when solving problems in organic chemistry	128	27	5	20	3.13
My teacher makes me like organic chemistry	97	52	18	13	2.77
My teacher always get me involved in the lesson	55	3	85	37	2.04
I do not see myself at the centre of learning during organic chemistry	58	73	22	27	2.98
We work in groups to find solutions to problems	5	14	85	76	1.93
My teacher does not vary his method and style of teaching	139	38	0	3	3.27
There is no better methods of teaching organic chemistry	77	51	36	16	2.98
I do not like organic chemistry because I do not know how to learn it	147	0	33	0	3.32
Chemistry is difficult especially organic chemistry	113	67	0	0	3.41

Source: 2022 Research Data

Note: SA=Strongly Agreed (4), A=Agreed (3), D=Disgreed (2), and SD=Strongly Disgreed (1) and X=mean

The questionnaire on students' attitudes and perceptions towards organic chemistry was administered before the intervention using the collaborative teaching and learning approaches (5E model of inquiry-based science instruction). The data revealed that many students do not like organic chemistry with the perception that it is difficult. Again, some items pointed to the way it is taught and many students'

response indicated that they do not think there are better methods of teaching organic chemistry. Furthermore, majority of the students responded that their chemistry teachers do not vary their approach and style of teaching.

Table 6: Experimental and Control Groups Post-Intervention Responses to Attitude and Perception towards Organic Chemistry Questionnaire

Item	Responses				
	SA	A	D	SD	X
The most interesting aspect of chemistry is organic chemistry	55	48	57	20	2.52
I get terrified working with structures of organic compounds	56	35	80	9	2.50
I easily get confused with the IUPAC nomenclature of compounds	25	55	62	38	2.11
It is not applicable in our daily lives and not important to learn	11	41	70	58	2.20
I love to attend organic chemistry class to engage in discussions	55	40	34	50	2.73
Organic chemistry is necessary for my future career growth	71	45	25	39	2.87
I do not enjoy any lesson in organic chemistry	66	31	55	28	2.54
It is boring when I participate in organic chemistry lessons	45	32	90	13	1.86
I become stressful in class during organic chemistry lessons	72	8	57	43	1.77
It makes me restless in class	50	32	77	21	2.61
I have good feelings towards chemistry in general except organic chemistry concepts	24	52	68	36	1.70
I feel nervous when solving problems in organic chemistry	58	17	50	65	2.53
My teacher makes me like organic chemistry	105	39	36	0	3.35
My teacher always get me involved in the lesson	111	18	41	10	3.04
I do not see myself at the centre of learning during organic chemistry	26	30	74	50	1.98
We work in groups to find solutions to problems	50	59	40	31	2.93
My teacher does not vary his method and style of teaching	52	22	52	46	1.97
There is no better methods of teaching organic chemistry	36	30	48	66	1.98
I do not like organic chemistry because I do not know how to learn it	55	6	78	41	1.82
Chemistry is difficult especially organic chemistry	77	22	45	36	2.61

Source: 2022 Research Data

From Table 6, the data revealed positive change in students' attitudes and perceptions towards organic chemistry. There was a 25% increment in the responses of students who disagreed to the statement that; they feel nervous when solving problems and questions in organic chemistry, and Chemistry is difficult especially organic chemistry. This indicated that students had gained confidence to study organic chemistry concepts after they were taught using collaborative models. Furthermore, there was a 20% positive change in students' negative attitudes and perception towards organic chemistry concepts. That is positive response to statements such as "I have enjoyed studying organic chemistry, and I have good feelings towards chemistry."

DISCUSSIONS

The chemistry students were taught organic chemistry concepts such as functional group identification, IUPAC nomenclature, and drawing of structures. The intervention for experimental group focused on such concepts using collaborative teaching and learning methods such as group discussions, peer teaching, and student-centred hands-on activities, 5E model of inquiry-based science instruction. Findings from the study are limited to the three schools in Tamale Metro that participated.

The findings revealed a statistically significant difference in performance in the post-test OCAT score where experimental group obtained mean score of 58.48 and control group scored 40.77. The difference in the mean scores produced a p-value of 0.02 which was less than 0.05, and hence significant. There was significant change in perception, behaviour, and attitudes of experimental group towards

organic chemistry. Therefore, it is unambiguous to state that the application of collaborative approaches such as group discussions, peer teaching, and students-centered hands-on activities are more effectual in ameliorating students' knowledge, understanding, attitudes, and perceptions of organic chemistry concepts.

Notwithstanding, the findings are in tandem with the findings of several other research conducted on the use of collaborative models for teaching and learning organic chemistry. Several of these studies within Ghana and in other geographical locations reported that the adoption and application of collaborative models were comparatively effective than the conventional methods of teaching.

A study by Yaayin et al. (2021) determined the effectiveness of jigsaw model that improved the performance of teacher trainees in functional group organic chemistry. The model used as an intervention on the teacher trainees improved their learning outcomes in functional group concepts. The improved performance by the experimental group was comparatively significant than the control group. According to Magen-Nagar & Shonfeld (2018), a study was conducted to investigate the influence of collaborative learning in an online programme on students' attitude towards technology. The outcome indicated that the use of online collaborative learning promoted positive attitudes of learners towards technology. It was further revealed that involving students in collaborative learning would reduce anxiety, increase self-confidence, motivation, and satisfaction.

In assessing the impacts of collaborative learning on learners' academic performance in chemistry in three selected SHSs of Nyamasheke District, Rwanda, Niyonsaba et al. (2022) reported that the experimental group that had intervention using collaborative learning methods outperformed those under the control group. Similarly, Bećirović et al. (2022) reported that cooperative learning as a collaborative learning approach provided motivation to students' learning and improved academic achievement. Furthermore, Dai et al. (2021) reported that project-based approach of teaching in organic chemistry, a collaborative model, improved students, self-learning abilities and positive attitudes towards organic chemistry.

CONCLUSIONS

It was found that the collaborative techniques were more effective than the non-collaborative approaches such as teacher-centred instructions. This agreed to similar revelations by some related studies in some parts of the world (Crimmins & Midkiff, 2017; Kumar, 2017; Niyonsaba et al., 2022). Their findings revealed an increase in the academic performance and high thinking order of students in organic chemistry through collaborative learning approaches.

There was significant improvement in the post test scores of the experimental group than the control group. Niyonsaba et al. (2022) in their groups' treatment using two different teaching methods, the experimental group that was trained through collaborative methods has their post-test scores improved significantly than the control group.

There was significant positive change in students' attitudes and perceptions towards organic chemistry. Prior to the treatment, the pre-test questionnaires revealed a larger number of students with misconceptions, certain perceptions and attitudes towards the concepts of organic chemistry. The post-test data from the questionnaires revealed significant positive change in students' attitudes, perceptions, and misconceptions. These findings agreed with several other findings in related surveys that saw significant positive change in students' attitudes, conceptions, and misconceptions towards the concepts of organic chemistry (Canelas et al., n.d., 2017; Sibomana et al., 2021).

DECLARATIONS

Declaration of Author Contributions
Authors declare that they have all contributed equally to the production of this article. They have all seen, read, and approved the final version ready for publication.

Declaring Conflicting Interest
All authors declare that there was no conflict of interest related to this article.

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