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Effect of Cooperative Learning Mode on Pre-Service Teachers' Academic Performance in Electrochemistry in Tertiary Institutions in Kwara State Nigeria

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Abstract: The study sought to determine the efficacy of cooperative learning mode (CLM) on pre-service (trainee) teachers' performance in electrochemistry. The target population for the study was all fourth year public pre-service (trainee) teachers in the faculty of education offering chemistry. The sample comprised of two university affiliates to Ekiti State university, EKSU, selected using purposive sampling technique with one being the experimental group and the other, the control group, both comprising of 70 (32 and 38) pre-service teachers of intact classes of respondents respectively. A quasi–experimental research design, specifically, a non- randomized pretest, posttest, control group design which involved a 1x3x2 factorial design was adopted for this study. The dependent variable was the pre-service (trainee) students' performance while the primary independent variable was treatment with cooperative learning mode, CLM, which was crossed with the secondary variable (moderator), the scoring levels (low, average, and high) and gender occurring at two categories (male and female). A 20-item multiple choice and 3-item theory Electrochemistry Performance Test, EPT, were generated from the course material. The instrument was subjected to both face validity and content validity by a senior lecturer in inorganic chemistry, after which it was administered on an intact class of a non-participating students of similar level in a sister institution to serve as the pilot study. A reliability coefficient of 0.72 and 0.77 were obtained using test-retest and split-half methods for the theory and objective test items. Three research questions and three null hypotheses were formulated respectively and tested. Data collected were analysed using mean scores, standard deviation and Analysis of Covariance, ANCOVA. Findings from the study showed that students in the experimental group exposed to CLM performed significantly better than those in the control group. Treatment also accounted for 46% students' improvement in their performance while score level accounted for 32%, thus attesting to the efficacy of CLM. Within the experimental group, low, average and high scoring pre-service teachers improved significantly in their performance and also when compared to the control group. Furthermore, within the group, low and high scoring students had the highest mean gain scores. Thus CLM was found to be effective in promoting better student-student interaction as observed in their verbal response to questions during the study. However, no significant difference was found between male and female students exposed to CLM. The implication of these findings is that CLM is an effective strategy of improving students' performance in learning chemistry. From the preceding report, it is recommended that CLM be incorporated into the curriculum to promote more effective learning as CLM is a general skill that could be very useful in adult life and society.

Keywords: *Cooperative Learning Mode; Traditional Teaching Method; Innovative Instructional Strategy; Pre-Service Teachers.*

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I. INTRODUCTION

Science education plays a significant role in a nation's effort towards achieving scientific and technological advancement. This explains why the National Policy on Education (revised edition, 2014) places emphasis on provision of quality teaching of science related subjects that will be consistent with the challenges of modern scientific and technological advancement aimed at producing the anticipated manpower for achieving social and economic development. Science has been variously defined by experts in terms of its methods or process (which is the dynamic way of knowledge acquisition and refining through reasoning and investigation), i.e. what scientists do (McCaslin, 2016; Ash, 2019; Davis, 2023), and; in terms of products, that is, knowledge in form of facts, principles, concepts, attributes, laws and theories. Science, defined in terms of its process, is one through which problems and

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questions dealing with natural phenomena can be identified, defined and solutions tested and proposed. As a process therefore, science finds relevance the more because through this, it advances. The knowledge of chemistry is needed for the scientific and technological development of a nation, and despite the gains in curriculum development and efforts made at implementing, and improving its content and teaching, reports from science education experts indicate underperformance and by extension, underachievement as, there is no indication of meaningful scientific and technological development from the knowledge acquired from it and other sciences; Graduates lack competence which requires integration of knowledge, skills and the necessary values (Bedada & Fita, 2023; Magwilang, 2016). This tends to affect chemistry learning outcomes, resulting in underperformance, which in turn affects the science teaching and learning in the classroom and by extension, scientific and technological development of a nation.

The ultimate purpose of education and of particular interest, chemistry teaching at all levels, is to provide quality education that prepare students for life after school and assist them in achieving both professional and personal goals. This makes the quality of teaching in schools, especially in higher institutions of learning crucial for a nation's workforce and economic competitiveness wherein quality education has been found to boost the economy, innovation, and the human capital development since it is at this level of education that those who are to teach at lower levels are trained. The continuous social changes in our society have affected the effectiveness of traditional method of teaching science subjects particularly chemistry. Students exposed to traditional approach of teaching often end up with poor understanding of scientific concepts, a result of promotion of rote learning over functional one (Agaba, 2013; Amoako, Oppong, Tabi & Ossei-Anto, 2022; Bedada & Fita, 2023). Dorothy (1999) in Iganga & Igboke (2024) reported that, 'the subject "chemistry" appears abstract to many students but the methods adopted in teaching it makes it real and close to the students'. Teaching of chemistry in schools is not adequate, leading to no meaningful scientific and technological progress (Ash, 2019; UN Technology, 2022; Utoikamanu, 2018); Nigeria does not manufacture equipment (is not technologically developed) because her school science of which chemistry is one, is weak (Emordi, 2006; Ibrahim, Adamu, Ibrahim & Imaila, 2022).

Several researchers are of the view that chemistry is not well studied in schools (secondary and tertiary) because students are stuffed with theories and little application due to poor state of laboratories in tertiary levels of education or complete absence of chemistry laboratory in secondary schools, us of obsolete materials in teaching the subject, lack of modern chemistry textbooks (Amoako, et al. 2022; Iganga & Igboke, 2015; Kramer, 2024); students are encouraged to learn by memorization without learning how (scientific) problems are solved (Folayan, 2004; Iganga & Igboke, 2015; UN Technology, 2022;); teaching method is mainly teacher-centered (Danmole & Adebayo, 2005; Dole, Bloom & Kowalske, 2016; Ezurike, Ayo-Vaughan, 2020); students are not encouraged to engage in critical thinking and self expression (Adewusi, Kazibwe & Odekeye, 2023; Brent, Prince, & Felder, 2021; Danmole Adebayo, 2005; Tzenios, 2022). With other developed society's continual technological improvements and modernity, it is critical to stay up with the advancements in instructional tools (Khan, Akhlaq, Qasim & Ahmad, 2023).

Science in general has almost always been perceived as difficult to learn by learners (Ana Luiza, Dayse, Fernando, Frank, Helga, Juliana, Sheila, Leandro & Gilson, 2016; Kramer, 2024; Nicoll, Francisco & Nakhleh, 2001) with the difficulty ascribed to lack of connections between concept areas and its application as exhibited by students in solving, for instance, problems related to electrochemistry. Learners have been described as "storing information in such a compartmentalized way that they are unable to transfer what is learned in one context to another situation" (Johnson, Johnson, & Smith, 2014; Novak, 2003; Reid & Yand, 2002). The learners will therefore fail to see the relevance of chemistry and connection with their everyday life, or their future. The quality of higher education may be determined by a variety of variables, both internal and external some of which include: good teaching methods such as project-based learning, experiential learning, and cooperative learning (which foster high positive level of social interrelationship among students and their teachers) amongst others. Skilled and experienced teachers can provide students with a great education and motivate them to thrive in their future professions by increasing their involvement in the learning process. Quality education, if given to trainee teachers, will produce graduates with strong employability and teaching capabilities.

A chemistry teacher has three basic functions to perform which are: teaching, supervision and management and/or utilization of learning facilities or resources. Poor pedagogical handling of subject matter leads to poor comprehension of chemistry concepts by pre-service teachers who depend largely on the teaching methods used by the lecturers who more often than not, use expository method only to teach mainly due to lack of knowledge of innovative instructional strategies that are and have taken place in educational practices. It is to be noted that the overwhelming use of didactic teaching method by lecturers in lectures will contribute significantly to learners' underachievement making knowledge learned to be perceived as a rigid body of facts as revealed by the authority (the teacher or textbook) and the learners' role is to return that knowledge to the authority (Bent, Prince & Felder, 2021; Johnson, et al., 2014; Tzenios, 2021; Zoller, 1990), making the learning of concepts, principles and theories not to be meaningful. The majority of teachers who have been employed in the past decades have been doing the same thing the same way all along as observed by Qinghua (2018).

Also, within a classroom setting, there is a limitation to student-teacher/lecturer and (pre-service) student-student interaction which, according to Johnson & Johnson (1999); Johnson, et al.; 2014, usually affects students' desire for clarification or explanation of terms, concepts, laws or theories during and after teaching exercise, a factor that affects learners' performance. Dedicated teachers therefore,

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will always be on the lookout for better ideas for meeting the challenges encountered during the teaching-learning process by engaging in the quest for approaches that will enhance better comprehension of scientific facts by the students. By so doing, the purpose of transforming knowledge acquired in chemistry into scientific breakthrough will be attainable thereby ensuring scientific and technological development form this part of the world.

A seemingly promising approach that can be used in chemistry learning is to focus on ways of organizing student-student (peer) interaction as postulated by Deutsch's (1949a) classical theory of cooperative and competition which according to him, serves as a premise for exhibiting a student-centered instructional strategy and has been noted for aiding in optimizing affective and meaningful learning. Hence, this study looked at the effect of cooperative learning mode on pre-service teachers' performance in electrochemistry.

II. STATEMENT OF THE PROBLEM

Performance of pre-service teachers in chemistry has been low, evidenced in their grades as explained by science education experts earlier thus, calling for improvement in their learning, understanding and application of chemistry principles, laws and theories. Areas of students' weaknesses which are generally prevalent are: poor interpretation of questions such as: Incomplete and vague answers; inability to tackle numerical problems to a logical end; omission of units of derived values which refers to a student's inability to accurately understand the meaning or intent behind a chemistry question, often leading to incorrect answers due to misreading key details, not recognizing relevant concepts, or simply not grasping the question's full context. This can be caused by factors like complex wording, unfamiliar terminology, or a lack of foundational understanding of chemical concepts by the teacher (Adebayo, 2008; Agaba, 2013; Amoako et al., 2022; Asbupel, Retnawati, Muhardis, Yovita, Munadi, 2020; Bedada & Fita, 2023; Ochoogor, 2018). Others are poor expression and use of non chemical terms; inability to apply theoretical knowledge to practical examination; evidence of lack of laboratory experience; poor mathematical skills among others (Adebayo, 2008; Amoako et al., 2022; Ali, 2012; Asbupel et al., 2020; Ochoogor, 2018).

Amoako et al., 2022; Brent, Prince & Felder (2021); Ochoogor, (2018); Olorundare (2005) all observed that studies by science educators have identified difficulties in specific areas in the content of chemistry along with the use of ineffective teaching methods and practices among other 'problems' identified. Some of these problems are the non utilization of problem solving strategies that promote critical thinking, meaningful learning and problem solving skills in students. Also, the topic chosen for the study (Electrochemistry) has been identified as a difficult one to learn as related above. Since they (pre-service teachers) will be the ones to teach the future generation of scientists in the country, there is the need to ensure that they do not just memorize to pass, but to have a meaningful learning of these scientific laws, principles and theories such that they will be able to let the learners they are being prepared to teach see the relationship between what they are learning in the classroom and everyday reality/living, thus have a conceptual understanding of the application of what they have learned.

The framework for the present study is hinged basically on advancements made in: the constructivists' epistemological view of knowledge which sees knowing as human construction Von Glasersfeld (1985); Deutsch's (1949a, 1963); classical theory of cooperation and competitive classroom interaction pattern and; Vygotsky's (1962, 1978) social interaction in learning. From these perspectives, learning outcomes do not entirely depend on what the teacher presents, but an active result of what information is encountered and how the student processes it based on perceived notions and existing personal knowledge. In the view of constructivists, learning is seen as a process change, where an individual's perceptions are recognized through an interaction between experiences and new information. This implies that learning involves the learner taking active role in building new knowledge by modifying their existing conceptions. The outcome of learning therefore depends on the nature of the interaction. In this regard, the present study is also influenced by Deutsch's (1949a, 1949b, 1962) and Vygotsky's (1962, 1978) analysis of the crucial role social interaction plays in learning.

Bauersfeld (1988); Johnson, Johnson, & Holubec, (1993) see social interaction as a process by which individuals create interpretations of situations that fit those of other purposes at hand. In doing so, the individual negotiate and institutionalize meanings, resolve conflicts, mutually take others' perspectives and more generally, construct consensual domains of coordinated activity. These comparative meanings according to them are continually modified by means of active interpretative processes as individuals attempt to make sense of situation in interacting with others. Social interaction therefore constitutes a crucial source of opportunity to learn in that the process of constructing knowledge involves what Piaget (1970a) calls cognitive conflict, reflection and active cognitive re-organization.

According to Tien, Roth & Kampmeir (2002; 2024); Quitadamo, & Crouch (2009), various science councils advise that the classroom should incorporate group activity because it influences how students learn and reinforce the collaborative nature of scientific enterprise (American Association for the Advancement of Science, 1989; National Research Council, 1996, 1999; National Science Foundation, 1996). This emphasis on student-centered instruction is a marked shift from the traditional teacher-centered paradigm, which provides few opportunities for students to become actively engaged in learning processes. Also, the Organization for Economic Cooperation and Development (OECD, 2020) conducted a study that revealed that countries that prioritize learner-centered teaching methods tend to outperform traditional teaching methods in academic achievement. The study found that countries such as Finland, Japan, and South Korea, which

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prioritize learner-centered approaches in their education systems, consistently rank among the top performers in international assessments of student achievement. Furthermore, the World Bank's report demonstrates that learner-centered teaching methods enhance student. In the same vein, several studies carried out on Deutsch's (1949a) classical theory of cooperative learning by educational researchers over time such as Johnson & Johnson 1989, 1999; Okebukola, 1986; Roka & Khatri, 2024; Yoruk, (2016), Seonghae, (2023); Zhidong & Liza (2023), reported that a veritable mode of learning that has been reported as effective in promoting learning among students and social interaction is cooperative learning mode (CLM).

The traditional goal structure used in majority of schools in Nigeria and perhaps in most part of the world is the competitive or individualistic interpersonal goal structure in which students are expected to outperform each other. Johnson & Johnson (1999; 2018) explained further that cooperative learning mode makes use of the fact that human enterprise and growth is hinged basically on the cooperative interaction between two or more people. Being a social animal, man cannot live alone. This also permeates in classroom practices where the individual student is never alone but always in working relation to the world of other students. If such situation is utilized using Deutsch's (1949a) classical theory of cooperative class learning mode, it is possible to help students help themselves to learn.

Empirical studies such as those of Thepkaew, Lerttherhan & Nithichaiyo (2024); Lestrade, Lima & Pansu (2024); and Siahaan, Simbolon, Saragih, Simatupang & Pasaribu (2024) on pre-service teachers/learners which looked at areas such as "experience to embrace opportunities, encourage collaboration and communication skills; "with the objectives to provide insights into the current state of knowledge"; and "active learning", found that undergraduate students could significantly improve entrepreneurial mindset; provided valuable insights for educators and researchers striving to enhance student engagement and academic success in online learning environments using cooperative learning and; a positive and significant relationship between the jigsaw type cooperative learning model and students' active learning. Their findings revealed that their participation in the cooperative learning programme significantly improved their academic ability in the areas investigated.

From literatures reviewed, few studies have been carried out in science, and specifically, in chemistry on cooperative learning. Therefore, it will be of important interest to science educators to see if cooperative learning mode (CLM) will promote meaningful learning as well as performance of pre-service teachers in electrochemistry.

"Mixed ability groupings" according to Dsouza, (2017); Wilkinson & Penny, (2024) refers to placing students of varying academic levels within the same classroom group, allowing them to learn together on the same topic, while the teacher adapts instruction to cater to different abilities through differentiation strategies, often proving beneficial for lower-achieving students by providing opportunities to learn from their peers with higher abilities, and fostering a collaborative learning environment. Literature contains mixed findings on the effects of mixed ability on performance or achievement within the small learning groups of cooperation and competition. Wilkinson & Penny, (2024) contended that ability grouping practices have a long and contentious history in educational policy, practice and research internationally, with little consensus on the best or most effective way of grouping students in schools. Some other previous studies have shown that mixed ability grouping in a cooperative learning mode class learning interaction pattern benefited all ability groups (Bowen, 2000; Dsouza, 2017; Wilkinson & Penny, 2024); high and mixed ability groups (Okebukola, 1984; Chakraverty, Chakraborty & Madan, (2022); Zamani, 2016); high ability groups (Esiobu & Soyibo, 1995; Adebayo, 2008); high ability and low ability group (Webb; 1982; Tai, Shen & Lin, 2011); low ability groups (Amaria, Biran & Leigh, 1969, Danmole & Adebayo 2008; Chakraverty, Chakraborty & Madan, (2022); Zamani, 2016). The differences in these findings according to Esiobu & Soyibo (1995) might be partly due to the differences with the ability composition within the small groups used in these studies. Studies generally indicate that mixed ability grouping in science can positively impact student engagement and understanding for all levels, particularly when teachers effectively differentiate instruction to meet individual needs (Dsouza, 2017; Wilkinson & Penny, 2024). Hence, this study revisited this issue under CLM.

Gender is rarely investigated as a predictor of interaction and achievement in small groups of mixed-gender groups. Along this divide, from literatures reviewed, not quite many studies exist in mixed ability groupings. Researches that explored the advantages and disadvantages of same- or mixed-gender composition of CLM groups have yielded divergent results with some studies of such groups showing no significant difference in achievement of males' and females' achievement (Adebayo, 2008; Esiobu & Soyibo, 1995; Hallam and Ireson (2006); Sari, Rod & Ben, 2023; Tereshchenko, et al. (2019). The findings of some studies suggest that mixed-gender groups enable the students to learn about the opposite gender, increase positive attitudes towards learning the content, and make learning 'more fun.' (Sari, Rod & Ben, 2023). But since males are believed to have more orientation towards a career in science, there is the need to look at the effect of gender on pre-service teachers' performance. For instance, in a large-scale survey of over 6000 Year 9 students from 45 secondary schools in England, for example, Hallam and Ireson (2006) found that …24% of the students expressed a preference for mixed-ability grouping in mathematics, english and science. Hallam and Ireson (2006) also noted a gendered dimension to ability grouping preferences, with boys showing a slightly greater preference for mixed-ability grouping (26%) than girls (21%). Hence, this study equally looked at mixed group along gender divide on pre-service teachers' performance in electrochemistry. Because of the lack of facilities used in determining the ability level of students, pre-service teachers' score levels, based on their scores in examinations

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in previous semesters were used in this study to place them into different ability levels.

III. OBJECTIVES OF THE STUDY

The study aims to examine the effect of cooperative learning mode, CLM on pre-service teachers' academic performance in electrochemistry in tertiary institutions. Specifically, the study aims to determine:

- The relative effect of cooperative learning mode on the performance of per-service teachers in electrochemistry;
- Whether or not scoring level will have any relative effect on pre-service teachers' performance using cooperative learning mode in electrochemistry and;
- Whether or not gender under cooperative learning mode will affect per-service teachers' performance in electrochemistry.

- *Research Questions*

- Which of cooperative learning mode and lecture method best improve pre-service teachers' performance in electrochemistry?
- Would mixed scoring (low, average and high) level affects pre-service teachers' performance when they are exposed to cooperative learning mode and lecture method in electrochemistry?
- Would there be any difference in the performance of male and female pre-service teachers' exposed to cooperative learning mode in electrochemistry?

- *Research Hypotheses*

- There is no significant difference in the performance of pre-service teachers exposed to cooperative learning mode and lecture method in electrochemistry.
- No significant difference exists in the performance of low, average and high scoring pre-service teachers exposed to cooperative learning mode in electrochemistry.
- There is no significant difference in the performance of male and female pre-service teachers exposed to cooperative learning mode in electrochemistry.

IV. METHODOLOGY

The study is a quasi-experimental one involving the use of two intact classes. The research design used is a non-randomized, non-equivalent pre-test post-test control group involving a 1x3x2 factorial model with all factors fixed (cooperative learning mode crossed at three levels of low, average and high scoring pre-service teachers and gender; male & female). Students' gender and ability were built in as independent moderator variables. This allowed for separate determination of main effects and interaction effects of the independent and moderating variables.

- *Sample and sampling Technique*

The target population for the study was all fourth year public pre-service teachers/trainee teachers in the faculty offering chemistry. The choice of year 4 pre-service teachers was informed by the fact that the chosen topic, electrochemistry is taught at this level in the chosen institutions. The sample comprised of two university affiliates to the parent university using purposive sampling technique. Also, the two affiliate institutions chosen were as far as possible apart so as to help eliminate or minimize contact/interaction between pre-service teachers in the experimental and control groups. The students were then be stratified into the three different score (low, average, and high) levels by using the scores of the previous semester/year in chemistry courses with the upper 25% as high level, the average as the middle 50%, and the lower 25% as the low level.

- *Research Instrument (Validation and Reliability)*

The research instrument (the test items and the mark guide) comprised of two sections: A & B, with both sections consisting of 20-item multiple choice (objectives) and 3-Questions theory Electrochemistry Performance Test, EPT. These two items were generated from the course material, also derived from the course guide/content of the university. The EPT (objectives test item and the theory) were so designed so as to ensure that the pre-service teachers' depth of understanding of the subject matter is adequate. The research instrument was subjected to assessment by a moderator (a professor of inorganic chemistry assessed and approved the questions as being of adequate standard and quality) thereby validating the face and content. Also, the instrument was trial tested using test-retest and split-half methods and Kuder-Richerdson-21 ($K\text{-}R_{21}$) formula was used to determine its reliability. A reliability coefficient of 0.72 and 0.77 were obtained for the objective and theory questions.

- *Procedure for Data Collection*

The study covered a semester (15 weeks). Other than the training on cooperative learning mode, all activities regarding the study was done within a regular semester. Treatment covered a semester i.e. 12 weeks of academic work and two weeks of pre and post-tests, making a total of 14 weeks. The research involved two groups; the experimental and control groups. Two weeks was used by the researcher to train the experimental group on the use of the cooperative learning mode. In each week, three special classes lasting an hour each were used to explain the basic principles of cooperative learning mode to the experimental group. Both lecturers in the participating institutions used the same course template since they are all affiliates to the same university. Both groups were taught using intact classes. At the beginning of the study, the test instrument was administered on both the experimental and control groups as pre-test.

The experimental group was exposed to cooperative learning mode, CLM, while the control group was taught using lecture method. The experimental group was divided into cooperative groups with each group comprising of 4 to 6 students, ensuring that all groups comprised of the three mixed scoring levels of low, average and high scorers as well as both gender. Important considerations when implementing mixed ability grouping as proposed by

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Johnson &Johnson, (1999, 2018) and Wilkinson & Penny (2024) was carefully followed: 1. Accurate assessment of student abilities: The researcher thoroughly assessed students' prior knowledge and current understanding to effectively differentiate instruction. 2. Flexible grouping strategies was considered using temporary groups for specific activities, allowing students to work with different peers based on their strengths in different areas. 3. Positive classroom culture was also fostered a supportive environment where students feel comfortable asking questions and helping each other. Thereafter, both experimental and control group were post tested.

Hawthorne effect, the effect caused by other extraneous variables such as history, maturation and experimental mortality, which could compound the results of the experimental design were minimized or eliminated by ensuring that the time interval between the pre- and posttest treatment was at least a month. Testing (being test wise) was controlled by rearranging the test items as well. Selection and statistical regression were eliminated by ensuring that students and groups were not selected based on their extreme scores thus ensuring that they are as comparable as possible prior to the administration of the experimental treatment. The arrangement of groups (of mixed scoring levels) helped to minimize interactions with selection (selection-maturation, selection-history and selection-instrumentation).

- *Data Analysis Technique*

All data collected from both pre-test and post-test were analyzed using mean, standard deviation to answer the research questions and Analysis of Covariance, ANCOVA to test the hypotheses at 0.05 alpha. The three hypotheses were tested for acceptance or rejection using because the study involves a non randomized situation. ANCOVA is well suited for the factorial design (1x3x2) used in the study because the variability in posttest scores that is shared with pretest scores can be partialed out or removed. ANCOVA is commonly used to detect a difference in means of 2 or more independent groups, whilst controlling for scale covariates. A covariate is not usually part of the main research question but could influence the dependent variable and therefore needs to be controlled for (Knox, n.d).

- *Result*

The following research questions were answered:

- *Research Question 1:*

Which of cooperative learning mode and lecture method best improve pre-service students' performance in electrochemistry?

To determine which of cooperative learning mode (CLM) and lecture method (LM) best improves students' performance in electrochemistry, the mean gain scores were calculated as shown in table 1.

Table1 Mean Gain Scores of the Experimental Group (CLM) and the Control Group (LM) in Electrochemistry.

Group	N	Pre-test	Post-test	Mean Gain Score
CLM	32	8.32	61.99	53.67
LM	38	11.81	17.06	16.25

Values of the mean gain score of the experimental and control groups indicates that there is a significant difference between the two groups (53.67>16.25) respectively. Students taught using CLM (the experimental group) performed better than those taught using LM (the control group).

- *Research Question 2:*

Would mixed scoring (low, average and high) level affect pre-service students' performance when they are exposed to cooperative learning mode and lecture method in electrochemistry?

Results on table 2 also used to determine which of the three scoring groups benefited the most when exposed to treatment with CLM.

Table 2 Comparison of the Mean Gain Scores (MGS) and Standard Deviation of Low, Average and High Scoring Students within the Levels of CLM in Electrochemistry

	Low	Average	High
N	10	14	8
Pre-test Mean	5.75	8.05	9.17
Post-test Mean	52.25	53.95	56.40
Mean Gain	46.50	45.90	47.22
Pre-test SD	2.60	3.83	4.98
Post-test SD	5.34	6.25	13.28

From table 2, within the levels of the CLM, the high and average scoring students had mean gains of 46.50, 45.90 and 47.22 respectively with the high scoring students having the highest mean gain followed by the low scoring ones with the average scoring students trailing (45.90<46.50<47.22).

- *Research Question 3:*

Would there be any difference in the performance of male and female pre-service teachers exposed to cooperative learning mode in electrochemistry?

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This was answered using the Mean Gain Scores of the male and female pre-service teachers exposed to CLM and LM in electrochemistry.

Table 3 Mean Gain Scores and Standard Deviation of Male and Female Students of the Experimental (CLM) and Control Groups (LM)

N	Pre-test Mean	Post-test Mean	Mean Gain	Males in
Males in:				
CLM	13	10.35	57.26	47.01
Pre-test SD	5.75			
Post-test SD	6.23			
LM	16	10.24	50.18	39.94
Females in:				
CLM	19	9.80	56.21	46.41
Pre-test SD	5.73			
Post-test SD	6.14			
LM	22	10.00	49.74	39.24

From table 3, it can be seen that the mean gain scores of both male and female pre-service students in CLM is about the same (47.01; 46.41) with significant improvements from both gender. The standard deviation for the experimental group for both the males and females also corroborate this finding. When the mean gain is compared with those of the control group (LM), the results suggest that both gender in the experimental group outperformed their counterparts in the control group.

V. RESEARCH HYPOTHESES

➢ *Research Hypothesis 1:*

There is no significant difference in the performance of pre-service teachers exposed to cooperative learning mode and lecture method in electrochemistry.

To determine the relative effectiveness of CLM, pre-service teachers' scores was analysed using ANCOVA as shown on table 4.

Table 4 Analysis of Covariance of the Post-test scores of Students in the Experimental (CLM) and Control (LM) Groups, Scoring Levels and Gender in Electrochemistry.

Variation	SS	Df	MS	f	Sig. of f
Covariates (Pre-test)					
325.8	1	325.8	10.61	0.0005	S
Main Effects					
Treatment	1680.24 2	780.8	20.06	0.0001	S
Scoring Level	2476.41 2	1242.5	38.54	0.0001	S
Gender					
2.01	1	2.01	0.05	0.6873	NS
2-way Interaction					
T vs SL	2372.15 4	625.75	15.48	0.0001	S
T vs G	1789.71 4	398.83	5.76	0.0001	S
SL vs G					
889.39	2	401.59	5.76	0.0002	S

S=Significance of f at 0.005 alpha level; NS= f not significant at 0.005 alpha level; SS=Sum of squares; MS= Mean square

Table 4 indicates that there is a significant difference in the performance of students in the CLM group (f_{calc}(2.187)= 20.06>f_{table}=3.04). Hypothesis 1 is therefore rejected.

➢ *Research Hypothesis 2:*

No significant difference exists in the performance of low, average and high scoring pre-service teachers exposed to cooperative learning mode in electrochemistry.

Analysis of pre- and post-test scores of low, average and high scoring students exposed to CLM using ANCOVA is as shown on table 4 which shows a significant difference in the performance of pre-service students of low, average and high scorers (f_{calc} (2.187)) = 38.54 > f_{table} = 3.04). Hypothesis 2 is therefore rejected. A graphical illustration of the result is shown on figure 1.

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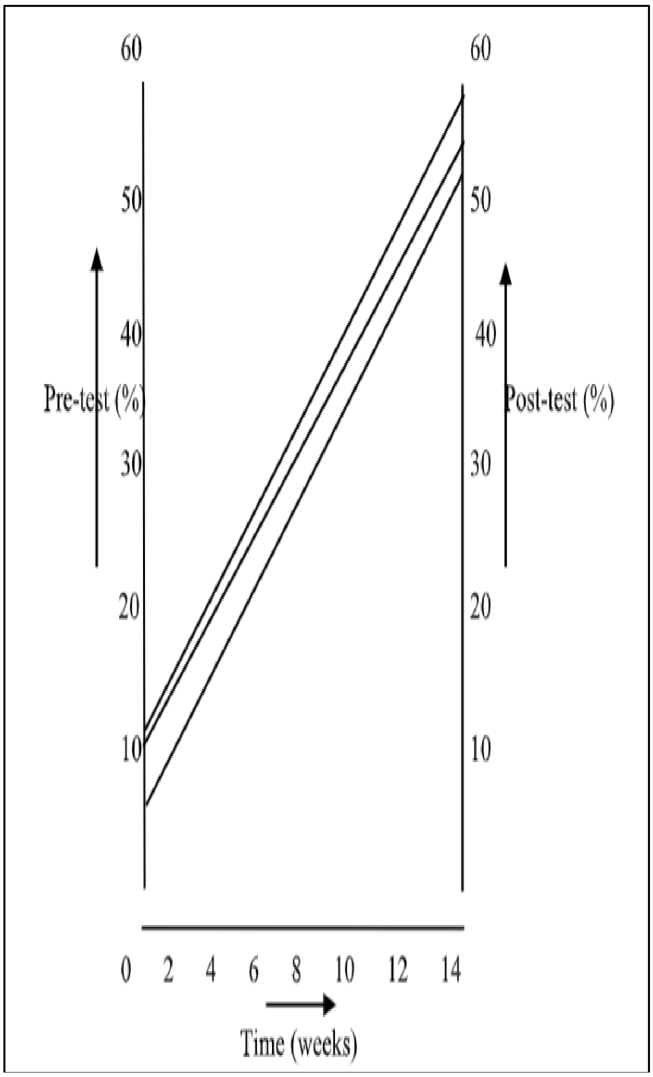

Fig 1 Graphical Comparison of the Pre- and Post-test Mean Scores and Pre-Service Students in Electrochemistry Exposed to CLM.

Figure 1 shows a graphical illustration of the comparison of the mean gain of low, average and high scoring pre-service students exposed to treatment. Within the CLM group, the high scoring pre-service students had the highest mean gain followed by the low scorers with the average scoring students having the lowest mean gain. $(45.90<46.50<47.22)$.

- *Research Hypothesis 3:*

There is no significant difference in the performance of male and female pre-service teachers exposed to cooperative learning mode in electrochemistry.

Results obtained from the analysis of the data suggests that over the period of treatment, no significant difference exists in the performance of male and female pre-service teachers taught using CLM as the calculated f value is less than the table value (f_{calc} (4.187)) = 0.05 < f_{table} = 2.01). Thus, hypothesis 3 was not rejected (see table 4). A graphical comparison of the pre- and post-test scores of male and female pre-service teachers taught using CLM is as shown on figure 2.

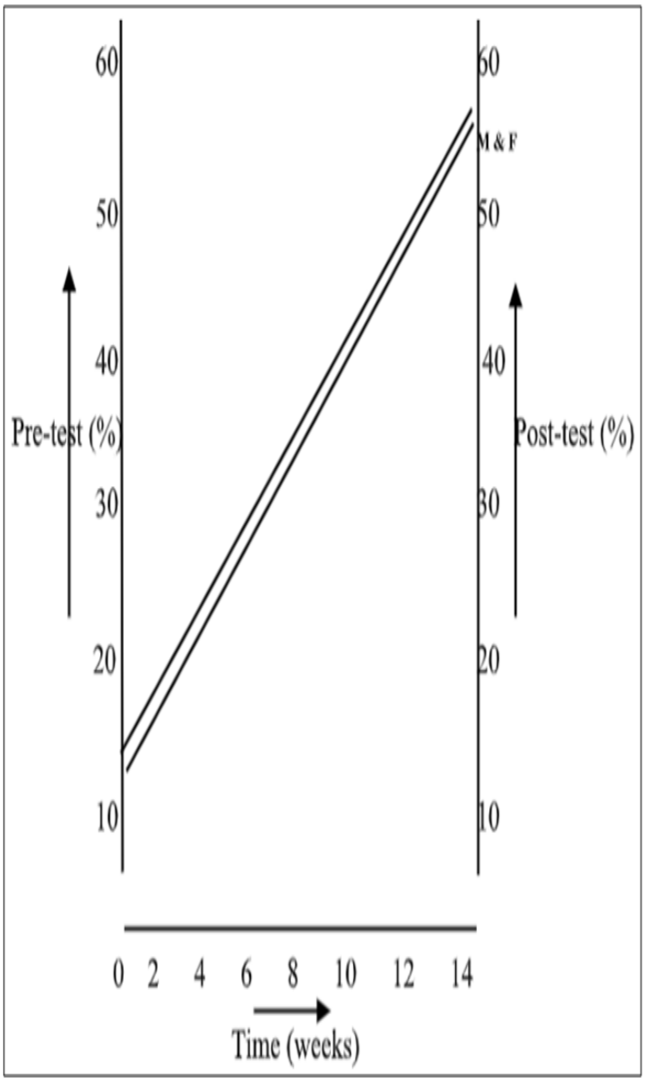

Fig 2 Graphical Illustration of the Comparison of Mean Scores and of Male and Female Pre-Service Teachers Exposed to CLM in Electrochemistry.

From figure 2, the mean gain scores of the male and female pre-service students taught using CLM in electrochemistry are about the same (57.36 ≈ 56.21). Both gender improved equally against the background of their pre-test scores in the period of treatment. The lines plotted for male and female run close to each other on the graph with identical gradients. Hence, instructional treatment, CLM, produced similar effect on the performance of male and female pre-service students in electrochemistry.

VI. DISCUSSION

Findings from the Analysis of Covariance of hypothesis 1 shows that pre-service teachers of chemistry exposed to cooperative learning mode, CLM, performed significantly better in electrochemistry than their counterparts exposed to conventional lecture method, LM only This finding agrees with those for previous studies of OECD (2020); Quitadamo, & Crouch (2009); Roka & Khatri, 2024; Seonghae, (2023); Tien, Roth & Kampmeir (2002; 2024); Yoruk, (2016), Zhidong & Liza (2023). In the words of Zhidong & Liza (2023), cooperative learning (CL) stands as an encompassing framework, bestowing educators

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with the tools to enrich the landscape of education, especially within the realm of science instruction. Also, Adebayo's (2008) study provided evidence attesting to the efficacy of CLM in enhancing better understanding of difficult concepts. The effectiveness of the learning mode may be partly attributed to the capability of the positive cathexis associated to the social interaction in the constructive peer – peer engagement in each group of CLM which was likely to have facilitated relatively better understanding of the concepts taught in electrochemistry. Thus, findings from this study confirm that CLM is indeed a powerful and effective instructional strategy for improving students; performance in electrochemistry.

Empirical studies as those noted above, consistently show that learner-centered teaching methods like CLM, compared to traditional teacher-centered approaches (LM), significantly improve student engagement, motivation, critical thinking skills, and overall academic achievement, with research highlighting positive impacts on learning outcomes like deeper understanding, long-term retention, and positive attitudes towards the subject matter; studies often cite active learning strategies like group discussions, brainstorming, and collaborative projects as key components of learner-centered pedagogy that contribute to these positive results (Dsouza, (2017); Iganga & Igboke, 2024; Tai, Shen & Lin, 2011; Thepkaew et al. (2024)); Wilkinson & Penny, (2024); Zhidong & Liza, (2023). Learner-centered methods have repeatedly been shown to be superior to the traditional teacher-centered approach to instruction, a conclusion that applies whether the assessed outcome is short-term mastery, long-term retention, or depth of understanding of course material, acquisition of critical thinking or creative problem-solving skills, formation of positive attitudes toward the subject being taught, or level of self-confidence in knowledge and skills (OECD, 2020).

Findings on the effect of scoring level on pre-service students' performance from the treatment drawn from the second hypothesis showed a significant difference in the performance of low, average and high scoring students. The improvement in the performance is supported by the study of Johnson & Johnson 1989, 1999; Okebukola, 1986; Roka & Khatri, 2024; Yoruk, (2016), Seonghae, (2023); Zhidong & Liza (2023) The result on table 5 suggests that treatment and scoring levels significantly improved the performance of all three scoring pre-service teachers in electrochemistry (see table 5 and figure 1). The results suggest that trainee teachers' scoring level accounted for a reasonable contribution (30.7%) to their performance which was enhanced further with treatment which accounted for 44% of the experimental group's improved performance over the pre-test scores. Treatment benefitted all ability groups with the highest mean gain scores in favour of the high scoring and the low scoring trainee teachers.

The expectation that high scoring students will have higher mean gain and outperform the low and average scoring students is so because of increased knowledge gain derived from the two other scoring trainees and most importantly, the potency of CLM in improving learners; understanding of previously vague understood concepts (Esiobu & Soyibo, 1995). Also, low scoring pre-service teachers in the experimental group had higher posttest mean gain score when compared with their counterpart in the control group. The finding may lend credence to the hypothetical proposal of the heterogeneous cooperative learning experience on the performance of low scoring students advanced by some researchers (Chakraverty, Chakraborty & Madan, (2022); Tai et al, 2011; Webb, 1982; Wilkinson & Penny, (2024); Zamani, 2016) that the stress-free learning condition created by CLM coupled with the positive interdependence and individual accountability, stimulate low scorers towards better and more productive learning. Apparently, these, conditions, which could lead to cognitive restructuring group members, might have benefitted the three scoring groups at varying degrees.

Research findings on mixed ability grouping in science which agreed with those of this study have shown the following success:1. Positive impact on achievement; 2. Improved self-esteem; 3. Social benefits 4. Benefits lower-achieving students from explanations and insights provided by higher-achieving peers, potentially boosting confidence and comprehension; 5. Benefits lower-achieving students by developing leadership skills by explaining concepts to others; 6. Deepen their understanding through teaching, and gain practice in applying knowledge to different situations. Utilizing cooperative learning activities within mixed ability groups has been observed to 6. further enhance learning by encouraging peer interaction and support; 7. can further enhance learning by encouraging peer interaction and support (Wilkinson, & Penny 2024).

Findings of the Analysis of Covariance on table 4 and figure 2 on the effect of gender on pre-service teachers exposed to CLM determined from hypothesis 3 shows a non significant effect of performance on gender. This implies that both gender performed equally well meaning that females can perform as well as males in electrochemistry. Hence, hypothesis 3 was not rejected. This is consistent with previous research findings which found that a significant difference does not exist in the performance of males and females taught using small heterogeneous learning groups (Adebayo, 2008; Dsouza, 2017;Esiobu & Soyibo, 1995; Hallam and Ireson (2006); Sari, Rod & Ben, 2023; Shinaberry & Hemmons, 2023; Tereshchenko, et al. (2019); Wilkinson & Penny, 2024.

Results from the findings on the interaction effects of CLM, score level and gender of pre-service teachers' performance in electrochemistry as observed from the results of Analysis of Covariance on table 4 showed significant joint effects of the three independent variables (T, SL, & G). The three variables interacted to determine pre-service teachers' learning outcome in the subject-matter. This implies that while treatment may have contributed significantly to their improved performance, their interaction in small heterogeneous groups of different ability levels and gender also played a significant role. This has not been reported in previous findings. The study also found a significant effect of the 2-way interaction effects of T vs SL, T vs G and SL vs G (table 4), implying that treatment

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improved students' performance on hypothesis 1 in small heterogeneous group. This result cannot be totally ruled out on performance when investigating innovative instructional strategies. Hence, it can be claimed that CLM promote social bond derived from the small heterogeneous groups' knowledge sharing in a friendly environment and peer assistance in the learning process.

VII. CONCLUSION

The findings of the study indicated that the experimental group exposed to CLM performed better than the trainee teachers in the control group that were exposed to LM. It thus be concluded that CLM improved pre-service teachers' understanding of concepts in electrochemistry and invariably, their performance. Findings from this study also indicated that unlike conventional LM commonly used in schools, small heterogeneous cooperative groups enable trainee teachers to actually receive individual attention denied them in traditional classes. Using CLM allowed the teacher to use more of the time to focus on specific learning problems of each student through proper teaching and sharing of knowledge as is characteristic of such cooperative groups.

Furthermore, findings from this study also shows that small heterogeneous groups made up of both gender and different ability levels promote more female participation in actively-oriented learning mode like cooperative learning which is known to enhance social interaction (Hallam and Ireson (2006); Sari, Rod & Ben, 2023; Tereshchenko, et al. (2019). Females were found to be capable of heading peer groups while interacting in a small social group tutoring each other. This means that irrespective of gender, any of male or female is quite capable of performing in electrochemistry. The implications of the findings of this study is that chemistry teachers should make effort to design and implement lessons that involve students actively in teaching and learning process and; also promote cooperative/collaborative learning among them.

RECOMMENDATIONS

Based on the findings from this study, it is recommended both the government and curriculum planners incorporate cooperative learning mode in the curriculum as general school skills since it would be needed in adult society. Also, science textbooks authors should do same in their textbooks or teachers' guide to textbooks using this instructional strategy as it simplifies learning.

REFERENCES

[1]. Adewusi, M. A., Kazibwe, S. & Odekeye, O. T. (2023). The perspectives of educators regarding the critical thinking abilities of students. Journal of Higher National Council for Education, 10 (2), 147-165.

[2]. Agaba, K. C. (2013). Effect of concept mapping instructional strategy on students' retention in biology. African Education Indices, 5(1), 1-8.

[3]. Ali, T. (2012). A case study of the common difficulties experienced by high school students in chemistry classroom in gilgit-baltistan (Pakistan), SAGE Open, 2012, 2(2), 1–13/209- 217, https://doi.org/10.1177/2158244012447299.https://www.researchgat e.net/figure/Anal ysis-difficulties-encountered-chemistry-students-in-a-stoichiometry-pre- test_tbl1_344178914

[4]. Amoako, S. K., Oppong, K., Tabi, J. A. & Ossei-Anto, T. A. (2022). Factors affecting trainees' performance in organic chemistry in colleges of education in Ghana. European Journal of Education and Pedagogy, 3(6), 97-102. Retrieved from: https://doi.org/10.24018/ejedu.2022.3.6.403

[5]. Asbupel, F., Retnawati, H., Muhardis, H., Yovita, S., & Munadi, S. (2020). Analysis of students' difficulties in answering questions on the chemistry national standardized school exams in Kupang. Retrieved from: Advances in Social Science, Education and Humanities Research, volume 528 Proceedings of the 7th International Conference on Research, Implementation, and Education of Mathematics and Sciences (ICRIEMS 2020).

[6]. Ash, H. (2019). Science as a product and a process. Retrieved from: https://www.scribd.com/presentation/425386716/Lesson-3-Science-as-a-Product-and-L Process on 1/01/2025

[7]. Bedada, T. & Fita, K. F. (2023). Causes of poor academic performance in chemistry at primary school students in Chiro town, Ethiopia. European Journal of Educational and Development Psychology, 11(1), 53-72. Retrieved from: https://doi.org/10.37745/ejedp.2013/vol11n15372 on 23/01/2025.

[8]. Brent, R., Prince, M. J. & Felder, R. M. (2021). Promoting and managing student-student interactions in Online STEM classes: Approaches and recommendations. International Journal of Engineering Education, 37(3), 797-813. Strategies for engaging students in group work in synchronous and asynchronous online courses, including discussion boards and team assignments and projects.

[9]. Chakraverty, S., Chakraborty, P. & Madan, M. (2022). Effect of different grouping arrangements on students' achievement and experience in collaborative learning environment. Interactive Learning Environments, 31(10), 6366-6378. Retrieved from: https://www.tandfonline.com/doi/full/10.1080/10494820.2022.2036764?src=recsys on 19/3/2025.

[10]. Danmole & Adebayo (2005). Effect of concept-mapping on junior secondary school students' performance in integrated science in Ilorin, Nigeria. Journal of African Educational Research, 3(1), 249-276.

[11]. Davis, D. (2023). Science is a process. Retrieved from: RockEDU.rockefeller.edu/d4p/science- is-a-process/#:~:text=Science on 23/9/2024.

[12]. Dole, S., Bloom, L. , & Kowalske, K. (2016). Transforming pedagogy: Changing perspectives from teacher-centered to learner-centered. Interdisciplinary Journal of Problem-Based Learning, 10(1). Available at: https://doi.org/10.7771/1541-5015.1538

[13]. Emordi, J. (2006). A One–day public hearing on examination malpractices by the senate committee on education. (Television broadcast series). Abuja. NTA. Network News.

[14]. Esiobu & Soyibo (1995). Effects of concept and vee mappings under three learning modes on students' cognitive achievement in ecology and genetics. Journal of Research in Science Teaching, 32, (9), 971-995.

[15]. Ezurike, C. P. & Ayo-Vaughan, A. F. (2020). Influence of teacher-centered and student-centered teaching methods on the academic achievement of post-basic students in biology in Delta state, Nigeria. Teacher Education and Curriculum Studies, 5(3), 120-124. Retrieved from: https://www.sciencepublish ing group.com/j/tecs doi: 10.11648/j.tecs.20.200.503. 21. https://www.researc hgate.net/publication/344239 377.

[16]. Hallam, S. & Ireson, J. (2006). Secondary school pupils' preferences for different types of structured grouping practices. British Educational Research Journal, 32(4), 583-599. Retrieved from: https://bera-journals.onlinelibrary.wiley. com/doi/10.1002/berj.40 00?at=R#berj4000-bib-0020 on 2/3/2025.

[17]. Ibrahim, M. S., Adamu, T. A., Ibrahim, A. & Imaila, I. I. (2022). Solving the problems of chemistry education in Nigeria: A panacea for national development. American Journal of Heterocyclic Chemistry 3(4):42-46. Retrieved from: https://www.researchgate.net/publication/374898529 _Solving_the_Problems_of_Chemist ry_Education_in_Nigeria_A_Panacea_ for_National_Development on 2/1/2024

[18]. Iganga, C. U. & Igboke, C. O. (2024). Challenges and way forward for teaching and learning of chemistry in a developing nation: case study of Ebonyi state secondary schools. Retrieved from: file:///C:/Users/PC/Downloads/IGANGA'S+PAPER.pdf on 10/1/2025.

[19]. Johnson, D. W., Johnson, R. T., & Smith, K. A. (2014). Cooperative learning: Improving university instruction by basing practice on validated theory. Journal on Excellence in College Teaching, 25(3&4), 85-118.

[20]. Johmson, D. W & Johnson, T. R. (2018). Cooperative learning: The foundation for active learning. Open Access Peer-Reviewed Chapter. Retrieved from: https://www.intechopen.com/ chapters/63639 on 4/3/2025.

[21]. Khan, I. J., Akhlaq, M., Qasim, F. & Ahmad, F., (2023). Analysis of the potential factors affecting the higher education quality using soft computing technique. Pakistan Journal of Emerging Science and Technologies (PJEST), 4, 2. Retrieved from: https://doi.org/10.58619/pjest.v4i2.111 on 26th December, 2024.

[22]. Kramer, N. J. (2024). Why do students struggle with organic chemistry? Retrieved from: https://www. linkedin.com/pulse/why-do-students-struggle-so-much-organic-chemistry- kramer-ph-d--cdvxc/ on 2/1/2024.

[23]. Knox, C. (n.d.). Encouraging academics to share statistics support resources. Retrieved from: file:///C:/Users/PC/Downloads/71_ANCOVA.pdf. (c) Joanne Rothwell. University of Sheffield. Statstutor community project www.statstutor.ac.uk

[24]. Lestrade, K., Lima, L. & Pansu, P. (2024). Challenges and opportunities of cooperative learning in synchronous distance education among adolescent and young adult learners. 8 th International Conference on Education and Distance Learning. ICEDL 2024, Jul,2024, Paris, France. (halshs-04685906)

[25]. Magwilang, E. B. (2016). Teaching chemistry in context: its effects on students' motivation, attitudes, and achievement in chemistry. International Journal of Learning, Teaching and Educational Research, 15(4), 60–68.

[26]. McCaslin, S. (2016). What is science as a process. Retrieved from: https://www.quora.com/What-is-science-as-a-process-and-definition-What-is-scientific-Or- rather-what-isnt-science-scientific on 2/12/2020

[27]. Ochoogor, C. E. (2018). Recurrent difficulties: Stoichiometry problem solving. . African Journal Educational Studies in Mathematics and Sciences, 14, 25-31. Retrieved from: file:///C:/Users/PC/Down loads/RecurrentDifficulties.pdf on 2/12/24. https://w ww.researchgate.net/figure/Analysis-difficulties-enco untered-chemistry- students-in-a-stoichiometry-pre-test_tbl1_34417 8914.

[28]. Qinghua, L. (2018). Improvement of chemistry teaching practice to deep learning: Advances in social science. Education and Humanities Research, (204). 4th International Conference on Economics, Social Science, Arts, Education and Management Engineering.

[29]. Quadros, A. L., CarvalhoDa-Silva, D., Silva, F. C., Andrade, F. P., Aleme, H. G., Tristao, J. C., Oliviera, S. R., Santos, L. J., DeFreitas-Silva, G. (2011).The knowledge of chemistry in secondary education: difficulties from the teachers' viewpoint. Educacion Quimca, 22 (3), 232-239. Retrieved from: https://ww w.elsevier.es/es-revista-educacion- quimica-78-artic ulo-the-knowledge- chemistry-in-secondary-S018789 3X18301393 on 2/1/2024.

[30]. Quitadamo, I. J., Brahler, C. J. & Crouch, G. J. (2009). Peer-led team learning: A prospective method for increasing critical thinking in undergraduate science courses. https://files.eric.ed.gov/fulltext/EJ 851877.pdf, 18,(1), 29-37. Retrieved from: Retrieved from: https://files.eric.ed.gov/fulltext/EJ851877.pdf on 12/01/25.

[31]. Roka, J. & Khatri, T. B. (2024). Impact of cooperative learning approach on students' achievement in mathematics. Journal of Educational Research and Innovation, 4(1), 59- 67. Retrieved from: https://nepjol.info/index.php/jeri/article/view/7 5790 on 2/3/2025.

[32]. Shinaberry, A. & Hemmons, E. (2023). Mixed ability groupings: Definition and importance. Retrieved from: https://study.com/academy/lesson/

ISSN No: 2456-2165 https://doi.org/10.38124/ijisrt/25jun772

mixed-ability-grouping-advantages-disadvantages.html on 20/12/2024.

[33]. Siahaan, D. W., Simbolon, R., Saragih, O., Simatupang, H. & Pasaribu, A. (2024). Pengaruh Model Pembelajaran Cooperative Learning Tipe Jigsaw terhadap Keaktifan Belajar Pendidikan Agama Kristen dan Budi Pekerti Peserta Didik Kelas XII SMK N 1 Siatas Barita Tahun. Pembelajaran 2023/2024. Retrieved from: https://journal.aripafi.or.id/index.php/tritunggal. DOI: https:/doi.org/10.61132/tritunggal.v2i3.675. Online Available: Septem ber 11, 2024.

[34]. Souza, G. (2017). Mixed ability grouping: Making differences count. International Journal of Advanced Research, 5(6), 467-471. DOI:10.21474/IJAR01/4434. Retrieved from: https://www.researchgate.net/publication/318344459_mixed_ability_grouping

[35]. Tereschenko, A., Francis, B., Archer, L., Hodgen, J. & Mazenod, A. (2019). Learners' attitude to mixed-attainment grouping: Examining the views of students of high, middle and low attainment. Research Papers in Education, 34,(4), 435-444.

[36]. Tai, D. W. S., Shen, S. P. & Lin, Y. W. (2011). The study of heterogeneous cooperative learning towards blended learning performance. Retrievd from: https://www.researchgate.net/publication/289438831 on 23/01/2025.

[37]. Thepkaew, J., Lerttherhan, P. & Nithichaiyo, E. (2024). Promoting entrepreneurial mindset of undergraduate students by using design thinking with cooperative learning. Retrieved from: https://www.researchgate.net/publication/383840141_Promoting_Entrepreneurial_Minds et_of_Undergraduate_Students_by_using_Design_Thinking_with_Cooperative_Learning on 10th September, 2024. DOI: 10.1109/iSTEM-Ed62750.2024.10663117

[38]. Tien, L.T., Roth, V. and Kampmeier, J.A (2002). Implementation of a peer-led team learning instructional approach in an undergraduate organic chemistry course. Journal of Research in Science Teaching, 39(7), 606-632.

[39]. Tien, L.T., Roth, V. & Kampmeier, J. A. (2024). A course to prepare peer leaders to implement a student-assisted learning method. Journal of Chemical Education, 81(9), 1313 - 1323.

[40]. Tzenios, N. (2022). Learner-centered teaching. International Research Journal of Modernization in Engineering Technology and Science, 4(12), https://www.researchgate.net/publication on 12 December, 2024.

[41]. UN Technology (2022). The state of science, technology and innovative in the least developed countries.https://www.un.org/tech nologybank/sites/www.in.org.technologybank/files/exe cutive_summary_en_the_state_of_science_technology_and_innovation_in _the_least_dev eloped_countries.pdf

[42]. Utoikamanu, F. (2018). Closing development gap in least developed countries. Retrieved from: https://www.un.org/en/chronicle/ article/closing-technology-gap-least-developed- countries on 2/1/2025.

[43]. Wilkinson, S. D. & Penny, D. (2024). Students' preferences for setting and/or mixed-ability grouping in secondary school physical education in England. British Educational Journal, 50(4), 1804-1830. Retrieved from: https://bera- journals.onlinelibrary.wiley.com/doi/10.1002/berj.=Meta Danalyses 20literature reviews20and,Sukhnandan 201998).

[44]. Woldeamanuel, M,, Atagana H., & Engida, T. (2014). What makes chemistry difficult? AJCE, 2014, 4(2), 31-43. Special Issue (Part I). Retrieved from: file:///C:/Users/PC/Downloads/ajol-file journals_480_articles_104070_submission_proof_104070-5665-28 0528-1-10- 20140605.pdf on 12/01/ 2025.

[45]. Zamani, M. (2016). Cooperative learning: Homogeneous and heterogeneous grouping of Iranian. Cogent Education,3(1). EFL learners in a writing context. Retrieved from: https://www.tandfonline.com/doi/full/10.1080/2331186X.2016.1149959#abstract on 19/3/2024.

[46]. Zhong, Y. (2024). Enhancing student engagement of a university EFL class through cooperative learning: An action research. Educational Research and Reviews, (6), 9, 1-6. DOI: 10.32629/rerr.v6i9.2623 ISSN Online: 2661-4634.