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Facilitating Academic Achievement of Students in Carbohydrate: Consideration of Jigsaw, Think-Pair-Share and Coop-Coop Cooperative Strategies

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Abstract: Worried by the poor performance of students in organic chemistry**,** this study examined the comparative facilitative effects of Jigsaw, Think-pair-share and Coop-Coop Cooperative Instructional Strategies on Achievement of students' in Carbohydrate aspect of Chemistry in Jalingo metropolis in Taraba State, Nigeria. The population of the study comprised 1936 Senior Secondary two students in all the 41 public schools in the study area. The sample consists of 322 students (184 boys and 138 girls). Achievement Test in Carbohydrate (ATC) made up of 50 multiple choice questions was used to collect data for the study. Kuder-Richardson (K-20) was used to estimate the reliability index of 0.86 for the ATC. To answer the research questions and test hypotheses, the research adopted the descriptive statistics (Mean, and standard deviation) and inferential statistics of Analysis of Covariance (ANCOVA). Based on the data collected and analyzed, it was found that students taught carbohydrates using Jigsaw cooperative instructional strategy performed significantly better than their counterparts taught using Think-pair-share and Coop-Coop Cooperative Instructional Strategy. There was no significant difference between the mean achievement scores of male and female students taught carbohydrates using Jigsaw, Think-pair-share and coop–coop cooperative instructional strategies. Interaction effects between instructional strategies and gender on achievement was not statistically significant. It was recommended that there should be workshop to address the use of Jigsaw to teach chemical concepts and operations to enable teachers of chemistry employ it. Chemistry teachers should give female and male students equal opportunities in the classroom to enable them achieve equally.

Keywords: achievement in chemistry, jigsaw strategy, think-pair-share strategy, coop-coop cooperative strategy, gender, achievement.

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Introduction

The functional role of Chemistry to science and technology is so multifaceted and multifarious that no area of science, technology and business enterprises escapes its application. Chemistry has contributed immensely to the production of food, drugs, building materials, textiles and modern transportation systems. These have led to improved living conditions for mankind. Studying Chemistry assists the development of knowledge, skills and attitudes which enrich people's lives and allow them to be scientifically capable members of society (Owoyemi, 2018). Any nation, therefore, that does not give attention to Chemistry education at all levels, cannot be expected to make any reasonable progress in economic, social, political, scientific and technological development. With the rate at which scientific and technological inventions are gaining popularity all over the world, the training of the mind is a must. Students need to be thoroughly equipped with relevant knowledge and skills that would make them functional in society and to cope with any intellectual or cultural challenges which the rapidly changing environment may demand in future, as well as take advantage of numerous career opportunities in Chemistry.

Chemistry has played major roles in global environmental issues, such as the release of pollutants and toxic substances and the production of non-biodegradable materials resulting in harm to the environment and living things, including humans (Owoyemi, 2018). Chemistry is one of the core subjects in senior secondary schools in Nigerian. Its inclusion justifies the recognition of its role in our day to day activities. The functional role of Chemistry as one of the science subjects in both national and global development cannot be overemphasized (Umanah & Udo, 2009). The study of Chemistry offers opportunities to develop an understanding of scientific methods and the ability to understand the living world of which man himself is a part. This has contributed to its popularity among other school subjects, especially the sciences. It is important therefore that Chemistry should be given priority attention in secondary schools.

The Secondary School Chemistry curriculum has a component of life Chemistry called Carbohydrate Chemistry. Carbohydrate plays a significant role in the overall development of every nation of the world, hence it is needful to lay a solid foundation in the learners to help them appreciate its relevance. This sub-discipline of Chemistry has practical applications in food and pharmaceutical industries, medicine, tissue engineering and agriculture (Besada et al, 2009; Sudha et al, 2014). Carbohydrates are organic compounds containing carbon, hydrogen and oxygen only.

Unfortunately, the teaching and learning of carbohydrates Chemistry have been burdened with challenges that prevent the optimum achievement of the objectives of Chemistry for national development. It is a well-documented fact in science education literature that many students in many countries of the world, at all levels struggle to learn carbohydrates Chemistry (Njoku, 2005; Oloyede, 2010; Jegede, 2012). Consequently, these students perceive carbohydrates Chemistry as a difficult aspect of Chemistry. This perception is reflected in their performance in the subject in external examinations such as the West African Secondary School Certificate Examination (WASSCE) and National Examination Council (NECO).

It is no gainsaying that in a typical Nigerian science classroom, the traditional lecture method still predominates. This method is teacher-centred, and the learners are not actively engaged in meaningful hands-on, heads-on and hearts-on activities. The learners only remain passive listeners struggling to memorise the concepts taught without actually understanding them. The resultant effect is poor learning,

poor perception of the concepts taught and poor academic achievement. The carbohydrates contents of Chemistry need to be properly taught using appropriate learner-friendly, interactive strategies.

There are varieties of student-friendly cooperative teaching strategies from which a teacher can select for facilitating learning and students' achievement in carbohydrate Chemistry (Olatoye & Adekoya, 2009). These include Jigsaw, Think-Pair-Share, Think-Pair-Solo, Numbered Heads Together, Co-op-Coop, Pantomime-A-Tale, Round-Robin brainstorming, Teams-Games-Tournaments and Student Teams Achievement Division to mention a few. The study, therefore, investigated the relative effectiveness of three variants of this strategy: Jigsaw, Think-Pair-Share and Coop-Coop Cooperative strategies in facilitating students' interest, achievement and retention of carbohydrate Chemistry in Jalingo Education Zone of Taraba State, Nigeria.

Jigsaw instructional strategy according to Mari & Gumel (2015) was developed by Elliot and was based on the idea that cooperation will develop each individual, and each individual can reach a goal only if all other individuals in the group reach their goals. In Jigsaw cooperative teaching strategy, the classes are broken into groups of 4-6 members and assigned tasks which are only parts of the lesson to be taught for the groups ('home groups`) to work on. Each student from every `home group` is assigned a portion of the material. Then the `home groups` members will disengage from the group and join other teams and form `expert groups` while in the `expert groups` the students study intensively their particular material to ensure that they understand it well and prepare it for peer tutoring. Later, each student returns to his/her respective home group he or she teaches his assigned material to the rest of his or her group and learns the other sub-topics from his/her peers in the group (Lestik & Plous, 2012). For example, the concept of carbohydrates might be divided into the definition of carbohydrate, sources of carbohydrate, reactions of carbohydrate, properties of carbohydrate. Each team member reads his or her section. Then the students return to their teams and take turns teaching their teammates about their sections. Since the only way students can learn sections other than their own is to listen carefully to their teammates. They are motivated to support and show interest in one another's work, by this jigsaw cooperative learning can bring children of different races and abilities together.

Think-pair-share is another cooperative instructional strategy used by teachers in mediating classroom interactions. The think-pair-share cooperative instructional strategy enables students to engage in higher-level thinking. This strategy provides students with the opportunity to think about a question, generate and revise their hypothesis as well as elicit their inductive and deductive reasoning (Hmelo-Silver, 2013). The strategy is defined as a multi-mode discussion cycle that is divided into three stages: Think that is students are given time to think individually after a question is posed; Pair where students discuss the ideas with each other within a paired setting to produce a final answer and finally Share where each pair shares their new improved answer with the rest of the class.

Another instructional strategy that is of interest in the present study is the Coop-Coop Cooperative Learning which was developed by Kagan (1989). In this structure, the instructor guides the process at each phase. Initially, the instructor explains the topic and breaks it into self-contained relevant sub-topics. Thereafter, the students are organized into 5-6memberred teams. The students may be permitted to self-select into teams. The teams discuss the instructor's defined topics and select one in which they have an interest. The instructor grants the topic to the teams. An alternative is to allow teams to create topics using the instructor's list as a starting point. However, if permitted, the instructor must ensure that all relevant sub-topics are addressed by the teams. Each team segments its topic into micro-topics for each team member. The team topic must be fully covered.

The instructor may want to retain approval rights for each team's micro-topic list. Micro-topics are independently prepared. This is followed by team presentations to the whole class. Micro-topic preparation may include library and/or database research, surveys, experiments, papers, videos, plays, or scenarios. After team presentations to the whole class, the teacher gives feedback to teams and necessary corrections and additional information on the topics presented. This is followed by testing the students on the subject matter and award grades. The present study investigated the efficacy of Jigsaw, Think-Pair-Share and Coop-Coop Cooperative instructional strategies in promoting interest in carbohydrate Chemistry.

Gender is another factor commonly associated with students' interest and academic achievement in the sciences. Gender, as a concept is a socio-cultural construct differentiating the roles of girls and boys in a given society; the physical, biological, mental and behavioural characteristics about and differentiating between the feminine and masculine (male or female) population. Gender issue in science education has attracted the attention of many researchers. Studies on gender as it affects students' academic performance in Chemistry are inconclusive, hence, needs further investigations. Some researchers consider science learning as a typical gender role–stereotyped domain in which boys and girls tend to be strongly conditioned by the self-perception of their competencies and skills. This, most at times, results in resistance and lack of self-confidence (typical in girls) or in overestimation and excess of desire to be in the limelight (typical in boys) (Cuomo et al., 2017).

The interaction effect between gender and strategies has received research attention in recent times in science education. For example, Ugwuanyi (2012) found that gender significantly interacts with instructional treatment. The interaction could come from the gender difference in the group that utilizes the cognitive conflict-based instruction. However, Miriogu (2012) and Musa (2017) found no interaction effect of gender and instructional treatments in physics teaching and learning. Given these research inconsistencies, further studies on the interaction effect of gender and cognitive-based instruction on performance become imperative.

Acknowledging the fact that the world has gone digital, students' alternative conceptions in carbohydrate Chemistry should not be allowed to go unchecked if students' interest, achievement and retention are to be enhanced. Hence, the need for this study, effects of Jigsaw, Think-Pair-Share and Coop-Coop Cooperative instructional strategies on students' interest, achievement and retention in carbohydrate Chemistry in Jalingo Education Zone of Taraba State, Nigeria.

Statement of the Problem

It is of note that both teachers and students of Chemistry at the secondary school level perceive some concepts in the Chemistry curriculum as difficult owing to teacher factors such as the use of inappropriate instructional strategies in communicating the concepts, and the teachers' poor pedagogical and content knowledge; and students' factors such as misconceptions about Chemistry as a subject, poor numerical background, and gender. Such concepts include organic Chemistry (in which carbohydrate is a component), chemical kinetics, electro Chemistry, and other quantitative Chemistry concepts. This situation is reflected in students' persistent and consistent poor performances in the subject in external examinations conducted by the West African Examinations Council (WAEC) and National Examinations Council (NECO) over the years. The observed state of students' underachievement in Chemistry in WAEC and NECO has caused serious concern to Chemistry teachers, educational planners and

parents. The teacher is said to be the most influential determinant of learners' learning outcome since his actions and inactions in the classroom situation exert a significant impact on the learners' perception of the topics taught.

It is also worthy of note that Chemistry is abstract, hence, needs to be properly taught using appropriate learner-friendly, interactive approaches to captivate and sustain the learner's interest during classroom interactions. To address the issue of inadequate involvement of the learners in teaching-learning situations Chemistry educators have recommended the use of student-friendly cooperative teaching approaches which include Jigsaw, Think-Pair-Share, Think-Pair-Solo, Numbered Heads Together, Coop-Coop, Pantomime-A-Tale, Round-Robin Brainstorming, Teams-Games-Tournaments and Student Teams Achievement Division. The question then is, which of these cooperative teaching strategies prove to be more effective in facilitating students' achievement in the concept of carbohydrates in organic Chemistry? There is a relative paucity of empirical studies in this area, hence, is difficult to assess the effectiveness of cooperative strategies in Chemistry, particularly in carbohydrates. The present study, therefore, seeks to fill this gap by investigating the relative effectiveness of jigsaw, think-pair-share, and coop-coop cooperative instructional strategies on students' achievement in carbohydrate Chemistry in Jalingo Educational Zone of Taraba State, Nigeria.

Purpose of the Study

The purpose of the study is to investigate the effect of Jigsaw, Think-Pair-Share, and Coop-Coop Cooperative instructional strategies on students' achievement in carbohydrate Chemistry in Jalingo Educational Zone of Taraba State, Nigeria. The specific objectives of the study are to:

1. Determine achievement scores of students in carbohydrate when taught using Jigsaw, Think-Pair-Share and Coop-Coop Cooperative instructional strategies
2. Find out the difference in achievement scores of male and female students in carbohydrate Chemistry when taught using Jigsaw instructional strategy
3. Determine the difference in the achievement scores of male and female students in carbohydrate Chemistry when taught using Think-Pair-Share instructional strategy
4. Determine the difference in the achievement scores of male and female students in carbohydrate Chemistry when taught using Coop-Coop Cooperative instructional strategy
5. Find out the interaction effect of instructional strategies and gender on the achievement of students in carbohydrate Chemistry

Method

Design

A quasi-experimental, non-randomized, pre-test, post-test design was employed for the study. The quasi-experimental design seeks to establish the cause-effect relationship of a given treatment. The design is considered appropriate because it is the most powerful and valid design which can be used to identify confidently the cause of any given effect (Emaikwu, 2015). The factors involved vary at the following levels: treatment - 3 levels, interest - 2 levels, and gender - 2 levels. It is therefore a 3 × 1 × 2 factorial design. The pre-test provides a check on the non-random assignment of subjects to groups.

Moreover, comparison based on pre-test performance provides a further process of equating the research groups.

The study was carried out in the Jalingo metropolis of the Jalingo Education Zone of Taraba State, Nigeria. The Education Zone is one of the ten education zones in Taraba State. It is composed of three Local Government Areas (LGS) of Ardo-Kola, Lau and Jalingo.

The population of the study comprised all the 1,934 SS2 Chemistry students in all the 41 public co-educational secondary schools in Jalingo Education Zone of Taraba State during the 2019/2020 academic session (Taraba State Post Primary School Management Board, 2020). The choice of Secondary School Two students is because carbohydrates are taught in Secondary School Two. Thus, it is assumed the students do not have any prior knowledge of the concept to be investigated.

Sample and Sampling

The study sample comprises 322 SS2 Chemistry students in six intact classes selected from six secondary schools in the study area. In the first stage, purposive sampling was used in selecting only co-educational public schools and schools that have presented candidates for the senior secondary certificate Examination (SSCE) in Chemistry at least for five years. The second stage, sampling random sample was used to select two schools from the six and assigned of Jigsaw Cooperative group experimental group I, Think-Pare-Share (Experimental group II) and coop-coop cooperative groups (Experimental group III), respectively. A pre-test was administered to SSII Chemistry Students in intact classes to determine equivalent achievement. The sample for the investigation was SSII male and female students that offer Chemistry. The numbers of students in the experimental groups were unequal because intact classes with different students' populations are involved in the study.

Instrumentation, Validation and Reliability

One instrument was developed by the researchers for data collection. The instrument is Students' interest in Chemistry Scale (SICS). In the same vein, twelve instructional packages (lesson plans) were prepared for the teaching. Four lesson plans for teaching in each experimental group, that is, experimental groups Jigsaw, Think-Pair-Share and coop-coop respectively.

The achievement test in carbohydrates Chemistry is a 50-item 4-option multiple-choice test with options (A-D) designed to measure the students' pre-test, post-test and retention achievement in the concept taught. The students were required to choose the correct answers from the options A-D listed against each question. The items in the ATC were selected from topics in carbohydrates listed in the Chemistry Curriculum in Taraba State based on Bloom's taxonomy of educational objectives in the cognitive domain. The multiple-choice items consisted of four options lettered A-D, one of the options is the key. Two marks will be given for correct answers to a question and no mark is given for correct answers or a choice of more than one answer for a question. The sample students are expected to answer the question in each of the tests. A total of 100 marks is the maximum obtainable marks in each of the instruments. The table of specifications of the questions reveals that most of the questions were on application, knowledge, comprehension and synthesis.

The instrument and twelve instructional packages were given to four lecturers, three from science education, one from Faculty of Science, Department of Chemistry for face validation. All the validators are from Taraba State University, Jalingo.

The validators were requested to scrutinize the items of the instrument in terms of their appropriateness to achieve the purpose of the study. They were also requested to ensure the relevance of the

contents and clarity of statements. The comments of the validators are seen as useful in modification of the instruments for trial data collection. The comments of the validators are seen on the instrument validated. The content validation covers 60 items. The 60 items to cover the topic of carbohydrates are to be taught to the students in the intact classes.

To determine the internal consistency of the instruments 40 copies of SICS were trial tested on (SSII) students in Jalingo Town of Jalingo Education zone of Taraba State, which is not part of the schools for the main study. Similarly, 40 copies of the ATC were administered on a sample of 40 SSII Chemistry students in Jalingo town of Jalingo Educational zone of Taraba State. The school is not part of the schools for the main study using Kuder-Richardson (K-R-20), the score obtained by the student in achievement test in carbohydrates Chemistry (ATC) were used to the reliability coefficient. The items reliability index was found to be .87. This value of the coefficient that was obtained indicates that the instrument is reliable and suitable for the main study. Moreso, the psychometric analysis was used to estimate the difficulty index, discrimination index and the distraction power of each item based on the results items with difficulty indices below 25 and above 70 were dropped for being too difficult and too simple respectively. Those with discrimination indices below 25 and above 70 were also dropped for lacking the potentiality to discriminate between the slow and fast learners. These reduced the items in ATC to 50 in the final form of the instrument.

More so, the selection of items was also based on the recommendation that for an acceptable choice item to meet the statistically acceptable criteria, any item that has both difficulty index (DF.I) p. value between .35 and .90 and discrimination index (D.I)>= .20 should be selected.

Data Collection

The ATC was administered to the groups as pre-tests by the researcher and the research assistant a week before the actual treatment to determine the level of students' interest and achievement. After the treatment session, the same test was administered as a post-test and subsequent retention test. Before treatment, the researcher trained and drilled six Chemistry teachers all of which are B. Ed or B. Sc (Ed) graduates as research assistants on the setting of the groups, as well as the strategy to be used in each of the groups. The research assistants used the prepared lessons plans to instruct the designated groups accordingly. Those trained for experimental group Jigsaw handled experimental group Jigsaw. Those trained for Think-Pair-Share and coop-coop handled experimental group, Think-Pair-Share and coop-coop. the training lasted for one week.

After selecting the sample schools and assigning them to the three treatment groups, the researcher visited and obtained permission from the principals of the three selected for the study to use their schools for the research and also solicited the cooperation of the SS2 Chemistry teachers in assisting as research assistants during the exercise. The research assistants were briefed for one week on how to teach their respective groups using the validated lesson notes developed by the researcher for the study. The use of the research assistants is to control for the treatment effect. At the end of the briefing session, the researcher assessed the research assistants' level of compliance and offered help where necessary.

This is followed by the administration of the Achievement Test in Carbohydrates to all the students in all the treatment groups as a measure of the respondent's interest in Chemistry and pre-test measurement respectively, by the research assistants under the strict supervision of the researcher. The pre-test serves as a covariate to control for the initial difference among the subject. Thereafter, the les-

son notes prepared by the researcher were used by the research assistants in teaching the concepts to their respective groups for four weeks. The students in treatment Group 1 were taught using the Jigsaw cooperative teaching strategy; those in treatment Group 2 were taught using Think-Pair-Share cooperative teaching strategy; while those in treatment Group 3 were taught using Coop-coop cooperative teaching strategy. The teachings in all the groups were done during the normal class periods for Chemistry and in an intact class setting. This was done to avoid disrupting the school programme, and treatment effect. At the end of the treatment session, the reshuffled version of the Achievement Test in Carbohydrates (ATC) was administered to all the treatment groups as post-test and subsequent retention test under the supervision of the researcher. Test scripts from both the pre-test and post-test administrations were collected immediately at the end of each test by the research assistants who submitted the same to the researcher for marking and scoring.

Analysis and Interpretation

The results of the data analysis and interpretation are presented according to the research questions and hypotheses formulated for the study. The data presented are analyzed using means, bar graphs and standard deviations to answer research questions. The hypotheses for the study were tested using Analysis of Covariance (ANCOVA) at .05 level of significance. The decision rule was that null hypotheses were rejected if the P-value was less than 0.05 and not rejected if otherwise.

Results

Research Question One

What are the mean achievement scores of students in carbohydrates when taught using Jigsaw, Think-Pair-Share and Coop-Coop Cooperative instructional strategies?

Table 1.

Mean Achievement Scores of Students in Carbohydrate when taught using Jigsaw, Think-Pair-Share and Coop-Coop Cooperative Instructional Strategies

Instructional Strategy		PreATC	PostATC	Mean Gain
Jigsaw	Mean	13.03	25.26	12.23
	N	108	108	
	Std. Deviation	4.98	9.49	
Think-Pair-Share	Mean	14.83	23.60	8.77
	N	107	107	
	Std. Deviation	3.12	6.81	
Coop-Coop Cooperative	Mean	12.60	17.76	5.16
	N	107	107	
	Std. Deviation	4.64	5.06	

Table 1 shows the mean achievement scores of students in carbohydrates when taught using Jigsaw, Think-Pair-Share and Coop-Coop Cooperative instructional strategies. The table shows that 108 students were taught carbohydrates using the Jigsaw instructional strategy, 107 students were taught

carbohydrates using the Think-Pair-Share instructional strategy and 107 students were taught carbohydrates using Coop-Coop Cooperative instructional strategy. The table further reveals that the mean achievement scores of students in carbohydrates when taught using Jigsaw instructional strategy is 13.03 with a standard deviation of 4.98 during pre-test and 25.26 with a standard deviation of 9.49 in post-test. The mean achievement scores of students in carbohydrates when taught using Think-Pair-Share instructional strategy is 14.83 with a standard deviation of 3.12 during pre-test and 23.60 with a standard deviation of 6.81in post-test. While the mean achievement scores of students in carbohydrates when taught using Coop-Coop Cooperative instructional strategy is 12.60 with a standard deviation of 4.64 during pre-test and 17.76 with a standard deviation of 5.06 in post-test. The table further shows that the mean gain for Jigsaw instructional strategy is 12.23, while that of Think-Pair-Share instructional strategy is 8.77 and Coop-Coop Cooperative instructional strategy is 5.16.

Research Question Two

What is the difference in the mean achievement scores of male and female students in carbohydrate Chemistry when taught using Jigsaw instructional strategy?

Table 2.

Mean Achievement Scores of Male and Female Students in Carbohydrate Chemistry when taught Using Jigsaw Instructional Strategy

Gender		PreATC	PostATC	Mean Gain
Female	Mean	12.74	24.67	11.93
	N	46	46	
	Std. Deviation	4.53	5.31	
Male	Mean	13.24	25.70	12.46
	N	62	62	
	Std. Deviation	5.31	9.89	
Mean difference				0.53

Table 2 shows the difference in the mean achievement scores of male and female students in carbohydrate Chemistry when taught using Jigsaw instructional strategy. The table shows that 46female students and 62male students were taught carbohydrate Chemistry using the Jigsaw instructional strategy. The table reveals that the mean achievement scores of female students taught carbohydrate Chemistry using the Jigsaw instructional strategy is 12.74 with a standard deviation of 4.53 during pre-test and 24.67 with a standard deviation of 5.31 in post-test. The mean achievement scores of male students taught carbohydrate Chemistry using the Jigsaw instructional strategy is 13.24 with a standard deviation of 5.31 during pre-test and 25.70 with a standard deviation of 9.89 in post-test, Table 2 further shows that the mean gain of female students that were taught carbohydrate Chemistry using Jigsaw instructional strategy is 11.93and those of male students taught carbohydrate Chemistry using Jigsaw instructional strategy is 12.46. The difference in the mean achievement scores of male and female students in carbohydrate Chemistry when taught using the Jigsaw instructional strategy is .53 in favour of male students.

Research Question Three

What is the difference in the mean achievement scores of male and female students in carbohydrate Chemistry when taught using the Think-Pair-Share instructional strategy?

Table 3.

Mean Achievement Scores of Male and Female Students in Carbohydrate Chemistry when taught using Think-Pair-Share Instructional Strategy

Gender		PreATC	PostATC	Mean Gain
	Mean	14.89	23.85	8.96
Female	N	46	46	
	Std. Deviation	3.27	6.75	
	Mean	14.79	23.41	8.62
Male	N	61	61	
	Std. Deviation	3.03	6.91	
Mean difference				.34

Table 3 shows the difference in the mean achievement scores of male and female students in carbohydrate Chemistry when taught using the Think-Pair-Share instructional strategy. The table shows that 46 female students and 61 male students were taught carbohydrate Chemistry using the Think-Pair-Share instructional strategy. The table reveals that the mean achievement scores of female students taught carbohydrate Chemistry using Think-Pair-Share instructional strategy is 14.89 with a standard deviation of 3.27 during pre-test and 23.85 with a standard deviation of 6.75 in post-test. The mean achievement scores of male students taught carbohydrate Chemistry using Think-Pair-Share instructional strategy is 14.79 with a standard deviation of 3.03 during pre-test and 23.41 with a standard deviation of 6.91 in post-test, Table 3 further shows that the mean gain of female students that were taught carbohydrate Chemistry using Think-Pair-Share instructional strategy is 8.96 and those of male students taught carbohydrate Chemistry using Think-Pair-Share instructional strategy is 8.62. The difference in the mean achievement scores of male and female students in carbohydrate Chemistry when taught using the Think-Pair-Share instructional strategy is .34 in favour of female students.

Research Question Four

What is the difference in the mean achievement scores of male and female students in carbohydrate Chemistry when taught using Coop-Coop Cooperative instructional strategy?

Table 4.

Mean Achievement Scores of Male and Female Students in Carbohydrate Chemistry when taught using Coop-Coop Cooperative Instructional Strategy

Gender		PreATC	PostATC	Mean Gain
	Mean	13.26	18.63	5.37
Female	N	64	46	
	Std. Deviation	4.89	5.28	
	Mean	12.10	17.10	5.00
Male	N	61	61	
	Std. Deviation	4.44	4.84	
Mean difference				0.37

Table 4 shows mean achievement scores of male and female students in carbohydrate chemistry when taught using coop-coop cooperative instructional strategy. The table shows that 46 female students and 61 male students were taught carbohydrate Chemistry using Coop-Coop Cooperative instructional strategy. The table reveals that the mean achievement scores of female students taught carbohydrate Chemistry using Coop-Coop Cooperative instructional strategy is 13.26 with a standard deviation of 4.89 during pre-test and 18.63 with a standard deviation of 5.28 in post-test. The mean achievement scores of male students taught carbohydrate Chemistry using Coop-Coop Cooperative instructional strategy is 12.10 with a standard deviation of 4.44 during pre-test and 17.10 with a standard deviation of 4.84 in post-test, Table 4 further shows that the mean gain of female students that were taught carbohydrate Chemistry using Coop-Coop Cooperative instructional strategy is 5.37and those of male students taught carbohydrate Chemistry using Coop-Coop Cooperative instructional strategy is 5.00. The difference in the mean achievement scores of male and female students in carbohydrate Chemistry when taught using Coop-Coop Cooperative instructional strategy is .37 in favour of female students.

Research Question Five

What is the interaction effect of instructional strategies and gender on the achievement of students in carbohydrate Chemistry?

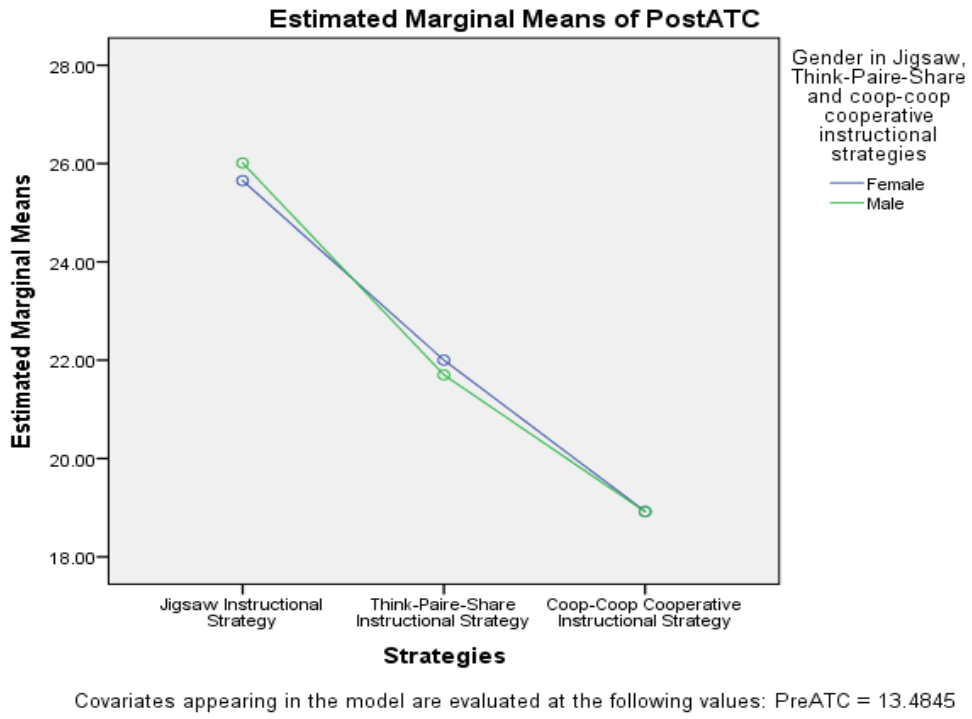

Figure 1. Interaction Effect of Instructional Strategies and Gender on the Achievement of Students in Carbohydrate Chemistry

In Figure 1, the profile plot/graph shows the interaction effect of instructional strategies and gender on the achievement of students in carbohydrate Chemistry. The interaction pattern shows that the plots for males and females intersect at Think-Pair-Share and Coop-Coop Cooperative instructional strategies. The plot further shows that the interaction effect of instructional strategies and gender on the achievement of students in carbohydrate Chemistry deviate at Jigsaw instructional strategy. This indi-

cates that there is an interaction effect of strategies and gender on students' achievement in Carbohydrate Chemistry.

Hypothesis One

There is no significant difference in the mean achievement scores of students in carbohydrates when taught using Jigsaw, Think-Pair-Share and Coop-Coop Cooperative instructional strategies

Table 5.

ANCOVA of achievement Scores of Students in Carbohydrate when taught using Jigsaw, Think-Pair-Share and Coop-Coop Cooperative Instructional Strategies.

Dependent Variable: Post-ATC

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	13639.752[a]	3	4546.584	207.420	.000	.662
Intercept	602.769	1	602.769	27.499	.000	.080
Pre-ATC	10307.681	1	10307.681	470.248	.000	.597
Strategies	2610.142	2	1305.071	59.539	.000	.272
Error	6970.462	318	21.920			
Total	179509.000	322				
Corrected Total	20610.214	321				

a. R Squared = .662 (Adjusted R Squared = .659)

Table 5 reveals that $F(2, 318) = 59.539$; $p = .000 < .05$. Since p is less than .05, the null hypothesis is rejected. This implies that there is a significant difference in the mean achievement scores of students in carbohydrates when taught using Jigsaw, Think-Pair-Share and Coop-Coop Cooperative instructional strategies. Thus, it can be concluded that based on evidence from data analysis there is a significant difference in the mean achievement scores of students in carbohydrates when taught using Jigsaw, Think-Pair-Share and Coop-Coop Cooperative instructional strategies. The partial Eta square of .272 was obtained for the strategy meaning that 27.7% of achievement scores of students in carbohydrates can be accounted for by the strategy employed.

Table 6.

Comparisons of Achievement Scores of Students in Carbohydrate when taught using Jigsaw, Think-Pair-Share and Coop-Coop Cooperative Instructional Strategies

Dependent Variable: Post-ATC

(I) Strategies	(J) Strategies	Mean Difference (I-J)	Std. Error	Sig.[b]
Jigsaw Strategy	Think-Pair-Share Strategy	4.030*	.648	.000
	Coop-Coop Cooperative Strategy	6.938*	.639	.000
Think-Pair-Share Strategy	Coop-Coop Cooperative I Strategy	2.908*	.654	.000

Table 6 shows the bivariate comparisons of the Instructional Strategies of teaching Carbohydrate and its effect on the mean achievement scores of students at P = .000 < .05 for Jigsaw Instructional Strategy and Think-Pair-Share Instructional Strategy. Again, comparisons of the Instructional Strategies of teaching Carbohydrate and its effect on the mean achievement scores of students at P = .000 < .05 for Jigsaw Instructional Strategy and Coop-Coop Cooperative Instructional Strategy. Similarly, comparisons of the Instructional Strategies of teaching Carbohydrate and its effect on the mean achievement scores of students at P = .000 < .05 for Think-Pair-Share Instructional Strategy and Coop-Coop Cooperative Instructional Strategy. Therefore, the rejected null hypothesis is confirmed and upheld. This implies that there is significant difference between the mean achievement scores of students in carbohydrate in the paired strategies when taught using Jigsaw, Think-Pair-Share and Coop-Coop Cooperative instructional strategies.

Hypothesis Two

There is no significant difference in the mean achievement scores of male and female students in carbohydrate Chemistry when taught using Jigsaw instructional strategy.

Table 7.

ANCOVA of Achievement Scores of Male and Female Students in Carbohydrate Chemistry when taught using Jigsaw Instructional Strategy

Dependent Variable: Post-ATCJS

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6879.840[a]	2	3439.920	130.729	.000	.713
Intercept	248.981	1	248.981	9.462	.003	.083
Pre-ATCJS	6852.386	1	6852.386	260.415	.000	.713
Gender JS	1.164	1	1.164	.044	.834	.000
Error	2762.900	105	26.313			
Total	78550.000	108				
Corrected Total	9642.741	107				

a. R Squared = .713 (Adjusted R Squared = .708)

Table 7 reveals that F(1,105) = .044; p = .834> .05. Since p is greater than .05, the null hypothesis is not rejected. This implies that there is no significant difference in the mean achievement scores of male and female students in carbohydrate Chemistry when taught using Jigsaw instructional strategy. Thus, based on evidence from data analysis there is no significant difference in the mean achievement scores of male and female students in carbohydrate Chemistry when taught using Jigsaw instructional strategy. The partial Eta squared of .000 is obtained for the gender meaning that Jigsaw instructional strategy does not account for the mean achievement scores of male and female students in carbohydrate Chemistry.

Hypothesis Three

There is no significant difference in the mean achievement scores of male and female students in carbohydrate Chemistry when taught using the Think-Pair-Share instructional strategy.

Table 8.

ANCOVA of Achievement Scores of Male and Female Students in Carbohydrate Chemistry when taught using Think-Pair-Share Instructional Strategy

Dependent Variable: Post-ATCTP

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1576.243[a]	2	788.122	24.559	.000	.321
Intercept	126.212	1	126.212	3.933	.050	.036
Pre-ATCTP	1571.212	1	1571.212	48.961	.000	.320
Gender TP	2.504	1	2.504	.078	.781	.001
Error	3337.476	104	32.091			
Total	64499.000	107				
Corrected Total	4913.720	106				

a. R Squared = .321 (Adjusted R Squared = .308)

Table 8 reveals that F(1, 104) = .078; p = .781> .05. Since p is greater than .05, the null hypothesis is not rejected. This implies that there is no significant difference in the mean achievement scores of male and female students in carbohydrate Chemistry when taught using the Think-Pair-Share instructional strategy. Thus, based on evidence from data analysis there is no significant difference in the mean achievement scores of male and female students in carbohydrate Chemistry when taught using the Think-Pair-Share instructional strategy. The partial Eta square of .001 is obtained for the gender meaning that only .1% of achievement scores of male and female students in carbohydrate Chemistry can be accounted for by the Think-Pair-Share instructional strategy.

Hypothesis Four

There is no significant difference in the mean achievement scores of male and female students in carbohydrate Chemistry when taught using Coop-Coop Cooperative instructional strategy.

Table 9.

ANCOVA of achievement Scores of Male and Female Students in Carbohydrate Chemistry when taught using Coop-Coop Cooperative Instructional Strategy

Dependent Variable: Post-ATCCC

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2318.966[a]	2	1159.483	299.432	.000	.852
Intercept	334.300	1	334.300	86.332	.000	.454
Pre-ATCCC	2257.411	1	2257.411	582.968	.000	.849
Gender CC	3.540	1	3.540	.914	.341	.009
Error	402.716	104	3.872			
Total	36460.000	107				
Corrected Total	2721.682	106				

a. R Squared = .852 (Adjusted R Squared = .849)

Table 9 reveals that F(1,104) = .914; p = .341 > .05. Since p is greater than .05, the null hypothesis is not rejected. This implies that there is no significant difference in the mean achievement scores of male and female students in carbohydrate Chemistry when taught using Coop-Coop Cooperative instructional strategy. Thus, based on evidence from data analysis there is no significant difference in the mean achievement scores of male and female students in carbohydrate Chemistry when taught using Co-op-Coop Cooperative instructional strategy. The partial Eta square of .009 is obtained for the gender meaning that only .9% of achievement scores of male and female students in carbohydrate Chemistry can be accounted for by the Coop-Coop Cooperative instructional strategy.

Hypothesis Five

There is no significant interaction effect of instructional strategies and gender on the achievement of students in carbohydrate Chemistry.

Table 10.

Interaction Effect of Instructional Strategies and Gender on the Achievement of Students in Carbohydrate Chemistry.

Dependent Variable: Post-ATC

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	13645.543[a]	6	2274.257	102.861	.000	.662
Intercept	599.390	1	599.390	27.109	.000	.079
Pre-ATC	10219.431	1	10219.431	462.207	.000	.595
Strategies	2533.969	2	1266.985	57.304	.000	.267
Gender	.024	1	.024	.001	.974	.000
Strategies * Gender	5.764	2	2.882	.130	.878	.001
Error	6964.671	315	22.110			
Total	179509.000	322				
Corrected Total	20610.214	321				

a. R Squared = .662 (Adjusted R Squared = .656)

Table 10 reveals that F(2,315) = .130; p = .878> .05. Since p is greater than 0.05, the null hypothesis is not rejected. This implies that there is no significant interaction effect of instructional strategies and gender on the achievement of students in carbohydrate Chemistry. Thus, based on evidence from data analysis there is no significant interaction effect of instructional strategies and gender on the achievement of students in carbohydrate Chemistry. The partial Eta square of .001 is obtained for the interaction effect meaning that only .1% of achievement of students in carbohydrate Chemistry can be accounted for by the interaction effect of instructional strategies and gender.

Discussion

Findings arrived at in this study are discussed in this section. The study investigated the effects of the use of Jigsaw, Think-Pair-Share, and Coop-Coop Cooperative instructional strategies on students' interest, achievement and retention in carbohydrate Chemistry in Jalingo Educational Zone of Taraba State, Nigeria. Since the population for the study consists of both male and female students, gender was incorporated as a moderating variable for comparison. Discussion of findings is tailored along with the variables in the study as guided by the results of research questions and hypotheses.

Findings revealed that there is a significant difference in the mean achievement scores of students taught carbohydrates using Jigsaw, Think-Pair-Share and Coop-Coop Cooperative instructional strategies. The bivariate comparisons of the Instructional Strategies of teaching Carbohydrate and its effect on the mean achievement scores of students confirmed and upheld the rejected null hypothesis. This means that carbohydrate Chemistry could be better taught using Jigsaw, Think-Pair-Share, and Coop-Coop Cooperative instructional strategies.

The finding agrees with that of Ogbonne (2012) that students taught statistics using the Kumon Strategy achieved significantly higher than those taught statistics using the conventional mastery teaching-learning strategy. The finding also agrees with that of Parveen & Batool (2012) that students taught using cooperative learning strategy achieved significantly better than those taught using lecture method. The finding also agrees with that of Eniang (2014) that students taught concepts in bookkeeping, banking and business calculations using Student-Centred Demonstration Method performed significantly better than those taught with Jigsaw and Coop Coop Cooperative Learning structure. The finding also agrees with that of Abed et al. (2019) that students taught concepts in-office procedures using Cooperative Learning Structures performed significantly better than those taught with Student-Centred Demonstration Method. However, the finding also disagrees with that of Achor & Wude (2014) that the Jigsaw strategy had significantly less positive effect on students' overall Biology achievement than group taught Biology using STAD. The finding also agrees with that of Adekunie (2015) that students taught with guided discovery and think-pair-share strategies obtained significantly higher posttest mean scores than those in the lecture strategy. The use of guided discovery and think-pair-share strategies had great potential for improving achievement in Chemistry and science learning generally.

Similarly, the finding also agrees with that of Ahmad (2018) that there is a statistically significant difference in favour of the environmental groups the first and the second lines in achievement. The finding also agrees with that of Abdulkadir (2016) that the jigsaw method increases students' academic achievement. The finding also agrees with that of Nwankwo & Okigbo (2021) that students taught using the Jigsaw Cooperative Instructional Strategy performed significantly better than students taught using the expository method. The finding also agrees with that of Yakubu (2016) that there is a significant dif-

ference in performance between students taught climate change using Field-based Teaching Strategy and those taught using lecture method. The finding also agrees with that of Udu (2018) that cooperative learning strategy enhanced students' academic achievement in organic Chemistry better than the conventional method. The finding also agrees with that of Ugan (2019) that primary III pupils taught using ethnomathematics teaching performed better than those taught with the conventional teaching method. The finding also agrees with that of Ojekwu & Ogunleye (2020) that that is a significant difference in science students' performance scores across the experimental and control groups in both cases, students taught with the Jigsaw strategy achieved greater improvement in their mean scores than those taught with the conventional lecture method.

Jigsaw instructional strategy was employed as a technique of teaching carbohydrate Chemistry in the present study because it has the goals of reducing racial tension and competitiveness in the classrooms, enhancing positive educational outcomes and helping students realize essential components of a whole as well as encouraging cooperation in a learning environment. Think-Pair-Share instructional strategy on the other is another cooperative instructional strategy used by teachers in mediating classroom interactions. The instructional strategies enable students to share ideas and then with other pairs or with the whole class. These may be responsible for the significant difference found in the mean achievement scores of students taught carbohydrates using Jigsaw, Think-Pair-Share and Co-op-Coop Cooperative instructional strategies.

Finding on the use of Jigsaw instructional strategy and gender revealed that there is no significant difference in the mean achievement scores of male and female students taught carbohydrate Chemistry using Jigsaw instructional strategy. This implies that the use of the Jigsaw instructional strategy is gender-friendly. The finding agrees with that of Ogbonne (2012) that there was no significant difference in the level of achievement of male and female students in statistics due to the use of the Kumon teaching strategy. The finding also agrees with that of Ajai & Ogbeba (2017) that there was no significant difference in the mean achievement scores between male and female students taught stoichiometry using hands-on activities. The finding also agrees with that of Areelu & Ladele (2018) that students exposed to the Jigsaw strategy had the highest post interest Score male students were above their female counterparts in all groups, while those of high SES had the highest post interest score.

Gender stereotyping permeates the Chemistry class when Jigsaw instructional strategy was used to teach thermal physics. The achievement of male and female students is found not significantly different. Chemistry has been seen as a masculine subject such as physics and mathematics. The use of the Jigsaw instructional strategy is expected to bridge such a gap as finding has shown that the instructional strategy is gender-friendly.

Finding on the use of Think-Pair-Share instructional strategy and gender revealed that there is no significant difference in the mean achievement scores of male and female students taught carbohydrate Chemistry using Think-Pair-Share instructional strategy. This implies that the use of the Think-Pair-Share instructional strategy is gender-friendly. The finding agrees with that of Busola (2011) that males performed better than females in the Chemistry achievement test. The finding also agrees with that of Eze & Obiekwe (2017) that male students exposed to think-pair-share instructional strategy achieved higher than their female counterparts. However, the finding disagrees with that of Ugan (2019) that there is no significant difference in the performance of male and female Primary III Pupils taught mathematical concepts using ethnomathematics teaching strategy.

Gender stereotyping permeates the Chemistry class when the Think-Pair-Share instructional

strategy was used to teach carbohydrate Chemistry. The achievement scores of male and female students taught carbohydrate Chemistry using Think-Pair-Share instructional strategy is found not significantly different. Chemistry is abstract, hence, needs to be properly taught using appropriate learner-friendly, interactive approaches to captivate and sustain the learners' interest during classroom interactions. The use of the Think-Pair-Share instructional strategy is expected to bridge any gender gap as finding has shown that the instructional strategy is learner-friendly concerning gender. The use of an interactive strategy such as the Think-Pair-Share instructional strategy enhances achievement scores of male and female students in carbohydrate Chemistry without bias.

Finding on the use of Coop-Coop Cooperative instructional strategy and gender revealed that there is no significant difference in the mean achievement scores of male and female students taught carbohydrate Chemistry using Coop-Coop Cooperative instructional strategy. This implies that the use of Coop-Coop Cooperative instructional strategy is gender-friendly. The finding agrees with that of Oludipe (2012) that there was no significant difference in the academic achievement of male and female students at the pretest, post-test and delayed post-test levels respectively. This finding implies that to encourage more women in pure science and science-oriented courses, interventions need to be designed that focus not only on the academic achievement of girls but also on how to make science-related occupations more interesting for young, high achieving girls. The finding also agrees with that of Yakubu (2016) that there is no significant difference in the performance of male and female students in the experimental group which implies the teaching strategy is gender-friendly.

The mean achievement scores of male and female students taught carbohydrate Chemistry using Coop-Coop Cooperative instructional strategy was found not significantly different. Students of Chemistry at the secondary school level perceive some concepts in the Chemistry curriculum as difficult owing to teacher factors such as the use of inappropriate instructional strategies in communicating the concepts, and the teachers' poor pedagogical. The use of Coop-Coop Cooperative instructional strategy is capable of ameliorating these challenges as finding has shown that the instructional strategy is gender-friendly.

The finding on the interaction effect of strategies and gender revealed that there is no significant interaction effect of instructional strategies and gender on the achievement of students in carbohydrate Chemistry. The non-significant interaction effect of instructional strategies and gender on the achievement of students may have come from the non-gender sensitivity of the instructional strategies. The finding agrees with that of Ajai (2011) and Achor et al. (2009) that there is no significant interaction effect of method and gender on students' achievement. The finding also agrees with that of Abdulkadir (2016) that gender does not affect students' academic achievement. The finding also agrees with that of Ajai & Ogbeba (2019) that there is no significant interaction effect between methods and gender on the mean achievement scores of students in stoichiometry. The finding also agrees with that of Tabiolo & Rogayan (2019) that Jigsaw II had a significant effect on the science achievement of learners and the class improved from "developing to proficient" level in their science achievement after implementation of the strategy.

The present study attributed the causes of the non-significant interaction effect of strategies and gender on students' achievement to the non-sensitive nature of the instructional strategies to gender. The reason to a large extent is that the students in their cooperative groups can discuss prior knowledge and ask questions related to the specific problem or issue, takes time to individually research or reflect on newly acquired information and areas that require further exploration, meet in small groups

and spend time to discuss the problem and present new information that may have been obtained during individual research. After such a meeting, students individually reflect on the information they had received during group meetings, thoughts regarding the problem or issues in question are compared. Then the group again meets to critically analyze individual and group thoughts and hold discussions to synthesize the information and draw some form of conclusions about a given problem.

Conclusion

The poor academic achievement of students' being recorded in both internal and external examinations in senior secondary school chemistry in Jalingo Education Zone of Taraba state, Nigeria calls for improvement in the mode and method of teaching and learning of the subject. This was one of the factors that necessitated this study, to identify other strategies of teaching chemistry in the secondary schools in Jalingo Education Zone.

Conclusively, this study has found out that;

1. The students' taught carbohydrates using Jigsaw Cooperative Instructional Strategy achieved significantly better than their counterparts taught using think–pair–share and coop-coop cooperative Instructional Strategies.
2. There is no interaction effect between instructional strategies and gender on students' achievement in carbohydrates.

Recommendations

The research findings recognize instructional strategy as the main obstacle in teaching and understanding carbohydrates and chemistry generally. In this respect the following solutions were recommended:

1. There is a need for workshop to address chemical concepts and operations using Jigsaw strategy to enable teachers of chemistry to employ the appropriate strategy (Jigsaw). The workshop can be divided into two: Chemistry teachers to know or to have an idea of chemical concepts, formulae, operations, etc. The second aspect of the workshop should concentrate on the technical knowledge of using Jigsaw to teach organic chemistry.
2. Chemistry teachers should give females and males equal opportunities in the classroom. This is because the result of the study shows that there is no significant difference between the mean achievement scores of male students and that of female students taught using a jigsaw, think-pair-share and coop-coop cooperative instructional strategies and so any of the three strategies is appropriate in coeducational classrooms.
3. There is need to enter Jigsaw Strategy within the teaching strategies used by student during the teaching and involvement of teachers in training courses on (Jigsaw) strategies and to conduct further studies on the strategy for another stages. Curriculum planners should incorporate Jigsaw instructional strategy into the curriculum of pre-science teachers.

Conflict of interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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