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Effect of Concept Mapping Teaching Strategy on Students' Misconceptions about Chemical Bonding in Rivers State

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ABSTRACT: This study examined the effect of concept mapping teaching strategy on Senior Secondary Students' misconceptions about chemical bonding in Rivers State. Mixed method design, specifically, exploratory mixed method design was adopted. The sample comprised 174 SS2 Students. The instruments were Chemical Bonding Misconceptions Diagnostic Test and Interview Schedule validated by two Science Education Lecturers. The reliability coefficient of 0.87 for the Chemical Bonding Misconceptions Diagnostic Test was determined by test-retest method using Pearson Product Moment Correlation Coefficient formula. Careful piloting of the interview schedule was carried out, and the use of scientific terms as well as discussions were avoided to ensure reliability of the interview schedule. Research questions were answered using percentage and hypotheses tested at 0.05 level of significance using Analysis of Covariance. Findings of the study revealed a remarkable reduction in the high extents of students' misconceptions about chemical bonding on the use of concept mapping strategy while negligible reduction was found with lecture teaching method. Also, statistically significant difference in the misconceptions of students taught with concept mapping strategy and those with lecture method was found. This suggests that students' misconceptions about chemical bonding were corrected on application of concept mapping strategy. There was gender related difference in misconceptions of students taught chemical bonding using concept mapping strategy. It was recommended among others that; teachers should embrace the use of conceptual change strategies such as concept mapping in teaching chemical bonding and other abstract concepts in chemistry. Also, students' misconceptions should be identified at the beginning of the lesson to facilitate correction.

Keywords: misconceptions, concept mapping, chemical bonding, and teaching strategy

INTRODUCTION

Learning is assumed to occur when the learner has acquired stated knowledge, understanding, values and skills to cognitively and physically apply knowledge, analyze and synthesize ideas, evaluate, create and modify knowledge [1-3]. The implication therefore, is that knowledge cannot be directly transferred from the mind of a teacher to that of a learner, rather students must actively construct their own knowledge by integrating new ideas into their existing knowledge base [4, 5].

Learners possess personal understanding of every event in the natural world which is "unique" and registered in their minds as "personal ideas". These ideas originate from interaction with components of the environment and are usually inadequate and different from generally acceptable point of view. They are tenaciously maintained as "the truth" and brought to classroom every day by the learners. During teaching, these preconceived ideas interfere with scientific concepts presented by the teacher and prompt students to construct ideas that differ from acceptable point of view and are called "misconceptions" [6], [4]. The term "misconception" has been offered different names such as naive beliefs, preconceptions, alternative frameworks, children's science, naive theories, naive conceptions, intuitive beliefs, intuitive science, learners' science, and misconceptions by researchers [7-11]. However, [12], defined misconceptions as a different idea, concept and subjects' thought that is different with scientific conceptions [13].

Misconceptions are stored in the learners' memory for long periods of time and may even be transmitted in the future. This can result in a decline in the cognitive process (way of thinking) or knowledge of learners dating back to the past and over the long term [14]. Misconceptions are well-embedded in students' cognitive structure and are very resistant to [15,16]. Furthermore, apart from the fact that, misconceptions hinder assimilation and accommodation of knowledge and provide a barrier to students' conceptual understanding, the problems of perceived concept difficulty and negative attitude of students towards sciences have also been attributed to misconception [17]. Misconceptions in science can be traced to different causes which may be teacher or student related. Some of these causes are: use of inappropriate teaching method, abstract nature of scientific concepts, analogies, over-simplified models in textbooks, students' personal experience and everyday language [18-20].

Learner's misconceptions can originate from a variety of different sources, nevertheless, the way science concepts are taught constitute pedagogic learning impediments. The order in which concepts are presented by teachers and even textbooks could serve as a potential source of misconception [13, 21]. Learning can only be meaningful when students' misconceptions are challenged using appropriate and innovative teaching. Through this process, students can be guided to construct new ideas which are "scientifically acceptable" [13]. One of such strategies is the constructivist teaching strategy which consider an individual as being responsible for acquiring his/her knowledge [2, 22, 23]. In the constructivist perspective, learning occurs when students' existing conceptions are changed or new knowledge is added [24] . This can only be achieved when the learner is actively constructing knowledge by either changing existing conceptions and adding new knowledge to what already exist or replacing the preconceived idea with scientifically acceptable ideas [6].

Concept mapping teaching strategy is an approach to teaching which utilize concept maps in the form of graphical tools to organize and present an individual's mental model or knowledge structure by creating relationship between a single concept and others in the same category in the form of prepositions [25], [26]. Concept map, according to [27] can be defined as a two-dimensional schema that illustrates mutual correlation or inter-conceptual relationship in graphics and help students to learn in a more meaningful way by relating old ideas to new ones in their minds. They are diagrammatic representations which show meaningful relationship between concepts in the form of prepositions. This kind of organization prevents the formation of misconceptions and results in the identification of relationships. Concept mapping has a lot of applications in the teaching and learning of various concepts in chemistry. Concept maps can be used as both instructional and performance assessment instruments. It helps teachers to identify students' misconceptions and provide information for lesson planning. Concept maps help students to analyze a given problem from different perspectives, develop a divergent way of thinking and enlarge their network of knowledge as well as their attitude for effective utility of concepts. It makes learning an active process, supports visual presentation and focus on concepts, makes learning easy, improves students' understanding and retention of information, and also helps the students in study and revision.

Chemical bonding involves the overlap of orbitals of some electrons in the outermost shell (usually called valence electron(s) of atoms of the same or different elements. These overlaps usually result in the formation of electrostatic force of attraction which hold the atoms or ions or molecules together, called "chemical bond". The process of formation of this bond is called chemical bonding. During reactions, these bonds are broken and rearranged to form new substance called "products" whose properties are different from the original ones. The theoretical basis for this study is rooted on cognitive learning theories of [5, 28]. These theories advocate student-centered approach to teaching as opposed to rote memorization of facts and hold onto the central emphasis that "meaningful learning can only take place when learners are actively involved in the process of knowledge construction" [5]. Accordingly, learners are responsible for knowledge construction and making meaning to all phenomenon. These individuals are strong opponents of rote learning. Many misconceptions about chemical bonding and other science concepts have been identified by different researchers. As a means of addressing this problem, other researchers focus on ways of eliminating or possibly reducing them to foster learning.

Findings of [29] in Rivers State showed that drama teaching strategy caused a substantial reduction in the high extents of students' misconceptions about chemical bonding. This infer that their misconceptions were eliminated as they were able to construct acceptable scientific ideas after the Intervention. The use drama and concept mapping strategies in teaching showed no significant difference in students' misconceptions Also, no gender related difference in students' misconceptions was found. In another study [30] found that imagination stretch teaching strategy was an effective strategy for correcting misconceptions of students about the particulate nature of matter in Nigeria. This strategy caused a significant reduction in students' misconceptions while lecture teaching method recorded persistence in the high percentages of students' misconceptions h. There was no significant difference between the misconception of students based on gender. Fatokun [31] in his study in Nassarawa State University showed that, some of the best student's misconceptions were removed during group's interaction and with the aid of concept maps, as they were enabled to apply their knowledge of concepts and their interrelations, as well as formulate appropriate theoretical explanations for the observed changes they viewed. Remarkable conceptual change and improvement in the knowledge base of the prospective teachers was obtained as their misconceptions were detected and dissolved.

Daminar's [32] findings showed that outcome-based teaching- learning computer assisted materials was effective in changing Flippino engineering students' conceptual understanding on ionic bonding and transformed most of their alternative conceptions into scientific conceptions. There was a statistically significant difference in students' conception between the per-test and posttest scores on students' conceptions. Students developed a better understanding of ionic bonding as a result of outcomes-based teaching and learning (OBTL) with computer assisted instructional material (CAIM). Hanson and Kwarteng's [27] findings revealed that concept mapping was useful in remediating chemistry teachers' trainee understanding of chemical phenomenon in University of Winneba Ghana. Increase in the percentages of trainees who gave correct responses in the post mapping was also recorded. Results of [33] showed that teaching with constructivism and analogy caused a significant improvement in the achievement of students by correcting their misconceptions. Significant difference was found between the achievement of students taught with two conceptual change strategies –constructivism and analogy and those taught with traditional method while there was no significant difference in achievement with regards to gender. Ihuarulam [34] found that application of intervention discussion learning model offered a very good conceptual change strategy for remedying students' misconceptions. Before treatment, students in both the experimental groups held relatively high percentages of the identified misconceptions between 42% to 80%. However, after treatment the misconceptions of students in experimental group were drastically reduced while those of the control group were minimal in reduction.

The study of [35] showed that the use of activity worksheet was very effective in correcting students' misconceptions in metallic bonding. A statistically significant difference was established on students mean score of diagnostic tests on the concepts of metallic bonding given before and after the lesson on the concepts, which indicate large effect of worksheet on metallic bonding in remediating students' alternative conceptions. Aytul [36] discovered that conceptual change-oriented instruction accompanied with analogies caused a significantly better acquisition of scientific concepts related to chemical bonding and elimination of misconceptions than traditionally designed instruction on Buyukelci Nazm Belger Primary School Ankra, Turkey. The study of [20] on the use of portfolios to correct alternative conceptions and enhance learning in Masvingo Province, Zimbabwe. revealed the effectiveness of portfolio as a tool for correcting students' alternative conceptions in chemical bonding and other concepts in chemistry. Also, monthly test scores improved significantly as the study progresses indicating correction of students' misconceptions by the use of portfolios. There was disappearance of the alternative conceptions as students got more familiar with the use of portfolios.

Statement of the Problem

The common method of teaching science concept in our schools today is the teacher-centered lecture method, notwithstanding its wide range of criticism as being limited in effectiveness in science teaching and learning. Moreover, students only assume a purely passive role, while the teachers play the active role and dominate the whole process of teaching and learning. Obviously, recent trends have shown that, regardless of teachers' attempt to address students' misconceptions with the existing conventional lecture method, most students always come out of science classes with various misconceptions about different science concepts. This is a clear indication that, this method of teaching has failed to provide solution to the problems of students' misconceptions. Consequently, the need for alternative teaching strategies that are useful in minimizing or possibly eliminating misconception need not be disregarded. Although researchers have explored various science concepts and teaching methods in the process of providing solution to this problem, the use of concept mapping pedagogy in addressing students' misconceptions has not been fully explored as there are limited studies in this regard. Moreover, there is no available study in Rivers State. This study is therefore an attempt to explore the use of concept mapping strategy in correcting students' misconception using chemical bonding as a specific concept in chemistry.

Research Questions

1. What is the extent of misconceptions for students taught chemical bonding using concept mapping teaching strategy and those taught with lecture teaching method in Senior Secondary Schools in Rivers State?
2. What is the extent of misconceptions for male and female students taught chemical bonding using drama teaching strategy in Senior Secondary Schools in Rivers State?

Hypotheses

HO1: There is no significant difference in the misconceptions of students taught chemical bonding using concept mapping strategy and those taught with lecture teaching method in Senior Secondary Schools in Rivers State.

HO2: There is no significant difference in the mean misconceptions of male and female students taught chemical bonding using concept mapping strategy in Senior Secondary Schools in Rivers State.

Methods

This study adopted mixed method research design. The instruments were a four-tier Chemical Bonding Misconceptions Diagnostic Test (CBMDT) and interview schedule. The instruments were validated by two Science Education Lecturers. The reliability coefficient of 0.97 for Chemical Bonding Diagnostic test calculated by Pearson Product Moment Correlation was considered appropriate. Careful piloting was carried out and discussion avoided to ensure reliability of the interview schedule.

Treatment (Intervention)

Students in each intact class were divided into two groups and randomly assigned – experimental and control. Pretest on chemical bonding was administered to both groups before intervention (Treatment). Students in control group received lesson on chemical bonding with lecture teaching strategy while those in experimental group were exposed to concept mapping strategy. They were taught how to construct concept until they attain a certain level of proficiency. Once this was achieved. The teacher allowed students to construct their own maps individually. The phases involved in construction of concept maps are:

Knowledge Generation

Student were asked to write down the main ideas on chemical bonding as they are remembered these ideas from what is called the "parking lot"

Idea Transformation

At this stage students arrange the generated ideas in hierarchical form for the purpose of refining and classifying ideas and thoughts into superordinate and subordinate ideas. These ideas are placed in circles.

Mapping

Related circled ideas are cross-linked with a line and labelled with suitable linking phrase or words in to give meaning to the relationship between the ideas. The study (intervention) lasted four weeks after which post – test was administrated to both groups.

Scoring

The scoring technique of [37] was adapted and modified for scoring students concept maps. In this technique, structural complexity and prepositional validity were the major basis for consideration. structural complexity was assed based on hierarchical design which considered student's ability to place subordinate ideas beneath superordinate ideas. This attracts 5 points each. Secondly, the cross-link indicates student's ability to give scientifically correct link between two segments of a concept map. It attracts 10 points each. Prepositional validity assesses non redundant, scientifically correct and meaningful linkage between two concepts. This attracts 1 point each.

Results

Research Question 1

What is the extent of misconceptions for students taught chemical bonding using concept mapping strategy and those taught with lecture teaching method in Senior Secondary Schools in Rivers State?

Table 1. Pretest and posttest misconceptions of students taught chemical bonding using concept mapping strategy and those taught with Lecture teaching method in Percentages

		Pretest		**Posttest**	
S/N	**Conception**	**CMS**	**LTM**	**CMS**	LTM
1	There must be transfer or sharing of electron(s) for chemical bonding to take place.	81.5	71.4	14.2	70.5
2	Atoms with incomplete electron in their outermost shell only undergo chemical bonding	51.8	60.1	5.3	45.2
3	Chemical bond is just an ordinary force that holds atoms together	69.5	60.7	15.7	42.6
4	There are only two types of chemical bonding - covalent and electrovalent	76.5	54.3	20.5	42.6
5	Coordinate covalent bond and Vander Waals are strong forces of attraction	80.8	65.5	10.5	56.8
6	Covalent bond is the shared pair of electrons contributed by the two atoms	69.8	89.5	11.2	69.2
7	Covalent bonding is formed between atoms of group 1& 2 elements	87.2	74.4	24.5	58.7
8	Electrovalent bonding is formed between atoms of group 6 & 7 elements	66.7	85.9	12.4	60.0
9	The properties of covalent and dative compounds are usually different	**53.7**	42.9	11.7	16.7
10	Hydrogen bonding does not affect the properties of the compound	75.3	54.3	12.8	43.2
11	Electrovalent bond is the only is bond that electrostatic in nature	71.2	62.8	10.2	51.2

CMS =Concept Mapping Teaching Strategy, LTM = Lecture Teaching Method

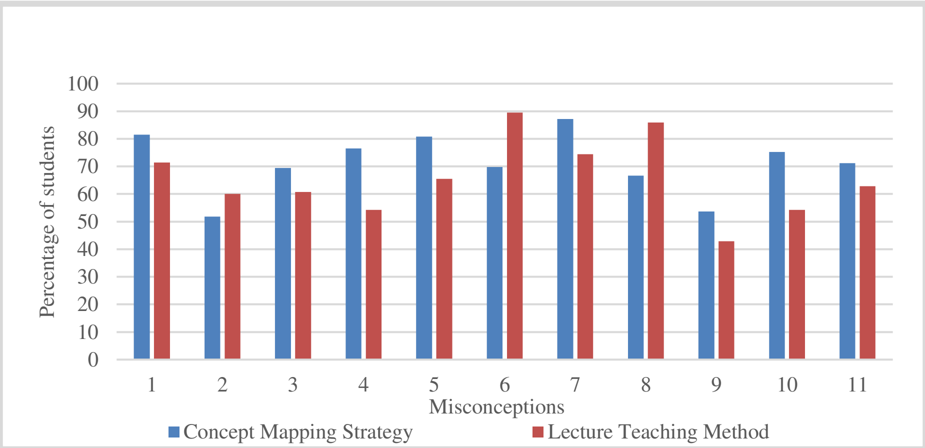

Figure 1. Pretest students' misconceptions for concept mapping and lecture teaching strategies

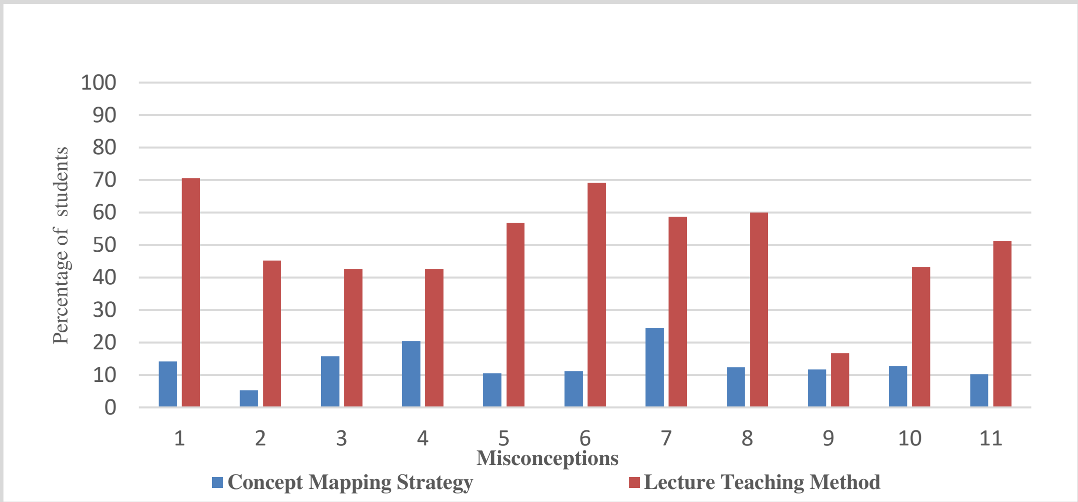

Figure 2. Posttest students' misconceptions for concept mapping and lecture teaching strategies

From Table 1 and Figures 1, before treatment, students taught chemical bonding using concept mapping strategy in experimental group and those taught with lecture method in control held various misconceptions to a very high extent (87.2 % - 51.8 %) and (89.5% - 42.9%) respectively. After treatment (Figure 2), there was a remarkable reduction in the high extent of misconceptions for students taught chemical bonding using concept mapping strategy to very low extent (24.5% - 5.3%) while those of students taught with lecture method persisted at high extent (70.5% - 42.6%), except misconception 9 with low extent of 16.7%.

Research Question 2

What is the extent of misconceptions for male and female students taught chemical bonding using drama teaching strategy in Senior Secondary Schools in Rivers State?

Table 2. Percentage misconceptions of male and female students taught chemical bonding using concept mapping strategy

		Pretest		Posttest	
S/N	**Misconceptions**	**Male**	**Female**	**Male**	**Female**
1	All chemical bonding involves transfer or sharing of electron(s)	76.0	88.0	29.4	17.5
2	Atoms with incomplete electron in their outermost shell only undergo chemical bonding	68.0	79.6	12.1	13.1
3	Chemical bond is just an ordinary force that holds atoms together	45.5	41.0	10.2	25.9
4	There are only two types of chemical bonding - covalent and electrovalent	63.1	57.8	15.7	12.3
5	Coordinate covalent bond and Vander Waals are strong forces of attraction	43.2	62.4	23.4	25.6
6	Covalent bond is the shared pair of electrons contributed by the two atoms	41.3	32.1	25.8	23.1
7	Covalent bonding is formed between atoms of group 1& 2 elements	74.0	58.4	17.5	25.7
8	Electrovalent bonding is formed between atoms of group 6 & 7 elements	78.2	25.4	8.8	21.8
9	The properties of covalent and dative compounds are usually different	86.4	91.7	18.9	24.4
10	Hydrogen bonding does not affect the properties of the	64.3	75.3	12.4	13.1

	compound				
11	Electrovalent bond is the only is bond that electrostatic in nature	52.8	71.2	8.8	15.8

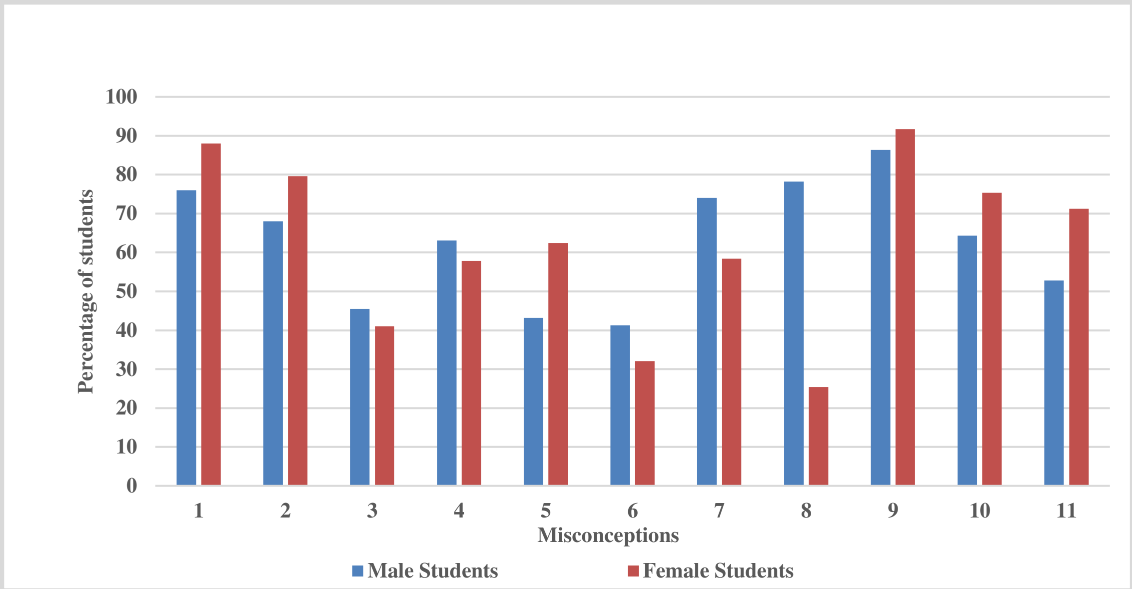

Figure 3. Pretest misconceptions for male amd female students' tauhgt with drama teaching strategy

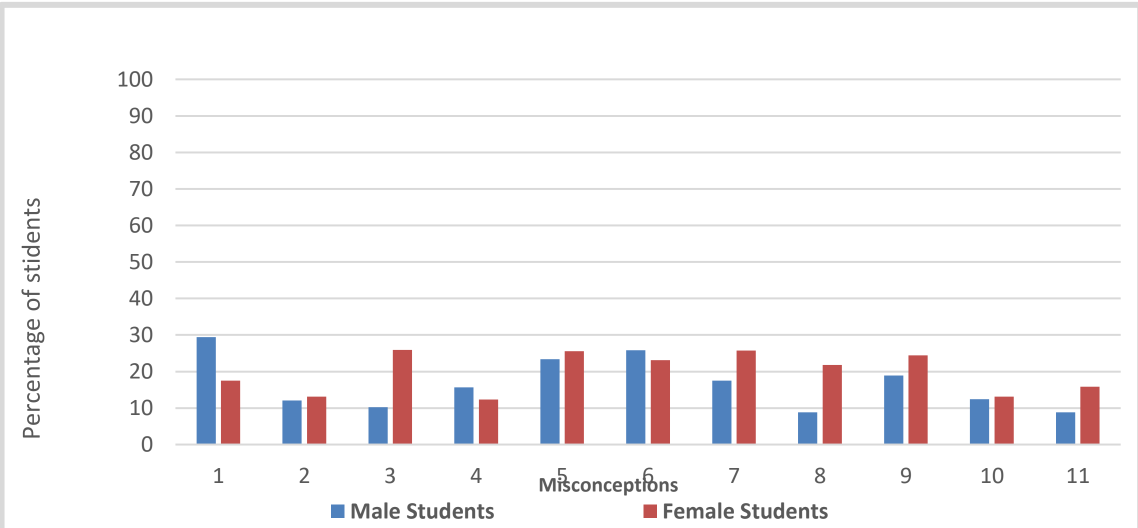

Figure 4. Pretest misconceptions for male amd female students' tauhgt with drama teaching strategy

From Table 2 and Figures 3, before treatment, male and female students taught chemical bonding using drama strategy held misconceptions to a very high extent (86.4% - 41.3%) and (91.7% - 25.4%) respectively. After treatment (Figure 4), there was a remarkable reduction in the high extent of misconceptions for male and female students taught chemical bonding using drama strategy to a low extent (29.4% - 8.8) and (25.7% - 12.3%) respectively.

Results of the Interview

The recorded version of students' interview on students' conceptions about chemical bonding in control(lecture), experimental group (concept Mapping) were transcribed and classified into two categories namely; misconceptions and scientific conceptions. Before treatment, high number of students held various misconceptions about chemical bonding in control experimental groups. After treatment, the interview results showed that the misconceptions of students in the experimental groups (concept mapping) were remarkably reduced to a minimal level while the misconceptions of the students in control group (lecture) persisted at high level. Excerpts from students' response during the interview session before and after treatment are shown below in (a) and (b) respectively.

Before Treatment

Conception 3

Researcher 1	:	I heard you mention that word "bonding" in your responses. Is there any difference between chemical bond and chemical bonding?
Student 1	:	No difference, I think we can also call it chemical bond instead of chemical bonding
Researcher 2	:	Since you said they come together, what really holds them?
Student 2	:	I think it is something like" super glue" but we cannot see it with our eyes and cannot see they are chemical combination
Researcher 3	:	What is the name given to the super glue?
Student 3	:	I think that may be chemical bond since we always say that the atoms bond together, that is combine together.
Researcher 4	:	Then, what is a "chemical bond"?
Student 4	:	It is a force that hold them and keep them together so that tied cannot move from one place to another. They are tied to each other as they combine together.
Researcher 5	:	What type of force holds them, and What do you call "them"?
Student 5	:	Sir, it is force just like any other force that keeps them together in one place. I have told you before "them" refers to the atoms

Considering chemical bond as "ordinary force" just like "any other force" by the student in the responses above, (S4 & S5) depicts lack of basic understanding that all chemical bond is electrostatic in nature. The knowledge is limited to that of the binding force that hold other thing together according to the illustration of super glue" (S2. Also, the existence of the force is only applied to atoms "leaving out" other basic particles such as ion and molecules.

Conceptions 4 & 5

Researcher 1	:	Then, how many types of chemical bonding do we have?
Student 1	:	They are only two" main types" of chemical bonding.
Researcher2	:	What do you really mean by "main type"?
Student 2	:	I mean; real chemical bonding.
Researcher 3	:	Is that all the type of bonding you know?
Student 3	:	Yes, the other ones I know are not "real" types of bonding
Researcher 4	:	what do you really mean by being "not real" types of bonding?
Student 4	:	I mean there is no transfer or sharing of electrons during the process
Researcher 5	:	What do you mean by "not real types" of bonding?
Student 5	:	It is because, in their process of formation, there is no sharing or transfer of electrons, all the atoms are stable. Also, they are formed from existing compounds with stable outer electronic structure. Any stable atom cannot undergo bonding again.
Researcher 6	:	Mention them?

Student 6	:	Coordinate covalent bonding, hydrogen bonding, metallic bonding and Waals.
Researcher 7	:	But in coordinate covalent bonding electrons are shared. In that case, Don't you think that it should also be considered as a "main type" of bonding?
Student 7	:	It is not a type of bond because only one atom, contribute the two electrons that are shared. The other atoms are cheating because they don't contribute but share the electrons.

From the students' responses above, the basis for classifying chemical bonding into electrovalent and covalent depicts erroneous notion of chemical bonding as the process of electron transfer or sharing (S1 & S3). Even when the knowledge of other types of bonding exist, they are not considered as "real bonding" simply because they do not transfer or share electrons. This conception originates from the students' belief on transfer or sharing of electron as the only condition for bonding is (S6 and S8). The student acknowledges that fact that there is electron sharing in coordinate covalent bonding, yet without proper explanation, it is not considered as a type bond S6).

Post-treatment Interview Results

Conception 3

Researcher 1	:	What type of element according to the periodic table form electrovalent or ionic bonding you mention?
Student 1	:	Elements that can donate or accept electrons
Researcher2	:	Do they belong to same group?
Student 2	:	No
Researcher 3	:	Which group does the elements that donate electrons belong to and what is the name of the group.
Student 3	:	the elements that donate electrons belongs to group 1, called alkali metals and group 2 called alkaline earth metals.
Researcher 4	:	What about the ones that accept electrons?
Student 4	:	elements that accept electrons belong to group 6 and group 7

The responses above show that the student have a good knowledge of the properties of atoms of the elements that form electrovalent or ionic bonding(S1) and can identify the groups they belong in the periodic table (S3 and S4) according to the properties of the elements in the periodic table. This conception is consistent with the scientific conception and confirms a change of conception

Hypothesis 1

HO_1: There is no significant difference between the mean misconceptions of students taught chemical bonding using drama teaching strategy and those taught with concept mapping teaching strategy in Senior Secondary Schools in Rivers State.

Table 3. Analysis of Covariance (ANCOVA) of misconception scores of students taught chemical bonding using drama strategy and those taught with concept mapping strategy.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1300.660[a]	2	650.330	4.066	.020
Intercept	10303.458	1	10303.458	64.427	.000
Pre-test	1297.375	1	1297.375	8.112	.005
Treatment	14.036	1	14.036	.088	.768
Error	18391.450	115	159.926		

Total	425861.000	118
Corrected Total	19692.110	117

a. R Squared = .066 (Adjusted R Squared = .050)

Table 3 shows that F (1, 115) = 0.088, *P*>.05. Therefore, the null hypothesis which states that there is no significant difference between the mean misconceptions of students taught chemical bonding using drama teaching strategy and those taught with concept mapping teaching strategy in Senior Secondary Schools in Rivers State is accepted. This infer that there is no significant difference between the mean misconceptions of students taught chemical bonding using drama teaching strategy and those taught with concept mapping teaching strategy in Senior Secondary Schools in Rivers State

Hypothesis 2

$_{HO2}$: There is no significant difference between the mean misconceptions of male and female students taught chemical bonding using concept mapping teaching strategy and those taught with concept mapping teaching strategy in Senior Secondary Schools in Rivers State.

Table 4. Analysis of Covariance (ANCOVA) on difference in misconceptions of male and female students taught chemical bonding using drama teaching strategy

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	3831.340[a]	2	1915.670	16.024	.000
Intercept	16955.490	1	16955.490	141.824	.000
Pretest	354.228	1	354.228	2.963	.087
Treatment	2258.170	1	2258.170	18.888	.000
Error	20443.516	171	119.553		
Total	537399.000	174			
Corrected Total	24274.856	173			

a. R Squared = .158 (Adjusted R Squared = .148)

Table 4 shows that F1, 171 = 18.888, *P*<.05. Therefore, the null hypothesis which states that there is no significant difference between the mean misconceptions of male and female students taught chemical bonding using drama teaching strategy and those taught with concept mapping teaching strategy in Senior Secondary Schools in Rivers State is rejected. This implies that there is a significant difference between the mean misconceptions of male and female students taught chemical bonding using drama teaching strategy in Senior Secondary Schools in Rivers State.

DISCUSSION

The convergence of results diagnostic test (Tables 1) and the interview schedule (4.6) for research question 1, revealed a remarkable reduction in the high extents (87.2 % - 51.8 %) and (89.5% - 42.9%) of misconceptions for students taught chemical bonding using concept mapping strategy to very low extent (24.5% - 5.3%) while those of students taught with lecture method persisted to high extent (70.5% - 16.7%). These results corroborate the findings of [35] where high percentages (between the range of 42% to 80%) of NCE students' misconception about chemical bonding and spontaneity in the experimental group were drastically reduced after treatment using the intervention discussion learning model (IDLM) of conceptual change strategy while those of the students in the lecture group were still in Kano State. This results further corroborate that of [32] where the use of concept maps caused the removal of some of the pre-service chemistry teachers' misconceptions about chemical bonding and a remarkable conceptual change with the corresponding improvement knowledge base of students. This enabled them to apply their knowledge of concepts and interrelations, as well as formulate appropriate theoretical explanations for the observed changes they viewed. This was the outcome of an action research attempted to detect and correct various misconceptions in chemical bonding retained by some pre-service chemistry teachers who were in their 3rd and 4th year in Nassarawa State University.

Remarkable reduction in students' misconceptions about chemical bonding to a minimal level in experimental group 1 where students were taught using concept mapping strategy suggests that students' misconceptions were corrected on the application of this strategy. This could be accredited to the fact that concept mapping which is a conceptual change approach based on constructivist strategy enables students' construction of new ideas which are scientifically acceptable from their preconceived ideas. With this, understanding of the scientific concept of chemical bonding is attained leading to the remarkable reduction of misconceptions. This lends credence to the posit of [36] that'll, for effective teaching of abstract concepts in chemistry to be achieved, students conceptual understanding must be enhanced. It further validates the view of [38] that conceptual change teaching approach encourage proper storage and retrieval of information as opposed to rote memorization in lecture method.

Moreover, in the concept mapping classroom, the teacher played the role of a facilitator, guiding students to construct their personal knowledge form preconceived ideas to arrive at scientific conception. Through this process, students' knowledge becomes the products of personal construction, because each student constructs his or her personal idea in line with scientific conceptions to attain conceptual change. This is different from what is obtainable in the lecture classroom where the teacher is the "ultimate source and dispenser of information" and transfer information to students who are passive listeners that depend solely on the teacher for information. This process encourages rote memorization of fact since knowledge is transferred and hinder proper understanding of concept in chemical bonding resulting in persistence of misconceptions of students in the lecture classroom. The convergence of results diagnostic test (Tables 2), figures 3 and 4 as well as the interview schedule (4.6) for research question 2, revealed remarkable reduction in the high extents of misconceptions for male and female students taught chemical bonding using drama strategy to a low extent. The evidence of this study implies that the use drama teaching strategy in correcting students' misconceptions about chemical bonding is not gender depended. Any strategy that is not gender discriminatory is considered a good strategy with high level of realization of lesson objectives.

Results of test of hypothesis 1 in 3 showed significant difference between the misconceptions of students taught chemical bonding using concept mapping strategy and those taught with lecture method ($F1, 108 = 204.858$, $P<.05$). This implies that concept mapping strategy is more effective in correcting students' misconceptions about chemical bonding than lecture method. Finding of this study is consistent with that of [31] where concept mapping teaching method was found to be more effective in improving students' achievement in chemistry than the traditional teaching method and students in experimental group taught with concept mapping performed significantly better than students in the control group taught with lecture method. Furthermore, the use of composite of both concept map and traditional lecture method of teaching was a better method compared to the use of either concept mapping or traditional lecture teaching method.

From the results of test of hypothesis 4 in Table 4.9, there is a significant difference between the mean misconceptions of male and female students taught chemical bonding using drama teaching strategy in Senior Secondary Schools in Rivers State ($F1, 171 = 18.888$, $P<.05$). Though, both male and female students attained low misconception scores in the diagnostic test, they differed significantly in scores. Findings of this study disagree with that of [29] and [30] where there was no gender effect on students' misconceptions. It further disagrees with results of the study of [33] where there was no significant difference in achievement of chemistry students with regards to gender. This was the outcome of a study on correcting students' chemical misconceptions using constructivism and analogy in Jos North Local Government Area of Plateau State.

CONCLUSION

Concept mapping is an effective strategy for correcting students' misconceptions about chemical bonding and related concepts. There is gender related difference in students' misconceptions.

Contributions to Knowledge

This study offers the following contributions to knowledge.

1. Findings of this study break the limitations and expands existing knowledge on applications of concept mapping teaching strategy in science teaching.
2. It offers teachers wider scope of selection for effective lesson delivery in science teaching

3. It adds to the existing body of knowledge on providing solution to the problem of concept difficulty in science.

Recommendations

Based on the findings of this study, the following recommendations were made.

1. Teachers should adopt concept mapping teaching strategy in teaching chemical bonding and other abstract science concepts.
2. Students' misconception should be identified by teachers in the course of lesson and effort made to correct them during lessons.
3. Teachers should always focus on assisting students to arrive at conceptual change through personal knowledge construction.

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