

Dramatizing Chemical Bonding Concepts towards Correcting Students' Misconceptions in Senior Secondary Schools in Rivers State, Nigeria.

ABSTRACT

Aims: Chemical bonding is a fundamental concept which provide essential information for interpretation of chemical reactions and understanding of related concepts in chemistry. This relevance notwithstanding, the general perception of most students is that chemical bonding as a topic is very difficult to understand. This study therefore, is an attempt to address this issue by using drama teaching strategy to correct students' misconceptions about chemical bonding Rivers State, Nigeria.

Study design: Mixed method design was adopted.

Place and Duration of Study: Science Education Department, Faculty of Education, Rivers State University, Port Harcourt, Nigeria. The study lasted about four months from June to October 2021.

Methodology: The sample comprised 170 SS2 chemistry students. The instruments were Chemical Bonding Diagnostic Test with reliability coefficient of 0.98 and Interview Schedule. Percentages and graphs were used to answer research questions and hypotheses tested at 0.05 level of significance using Analysis of Covariance.

Results: Results of the study revealed a remarkable reduction in the high extents of students' misconceptions about chemical bonding on teaching with drama strategy while the students taught with lecture method maintained a high extent of misconceptions. This implies that, misconceptions of students taught chemical bonding with drama strategy were corrected while that of the students taught with lecture method were not corrected. A significant difference in misconceptions of students taught chemical bonding with drama and those with lecture method was obtained. Also, there was a significant gender related difference in students' misconceptions about chemical bonding.

Conclusion: Drama teaching strategy is effective in correcting students' misconceptions about chemical bonding and other related concepts. Also, there is gender related difference in misconceptions based on gender.

Key Words: bonding, drama, lecture, teaching strategy and misconceptions.

1. INTRODUCTION

Chemical bonding involves the overlap of atomic orbitals of the same or different elements which usually result in the formation of electrostatic force of attraction that hold atoms or ions or molecules together, called “chemical bond”. During reactions, chemical bonds are broken and rearranged to form new substances whose properties are different from the original ones called “products”. Ideally, chemical phenomenon can be explained at three levels - the macro, sub-microscopic and symbolic levels which are connected to each other in such a way that none is superior, rather they complement each other [1].

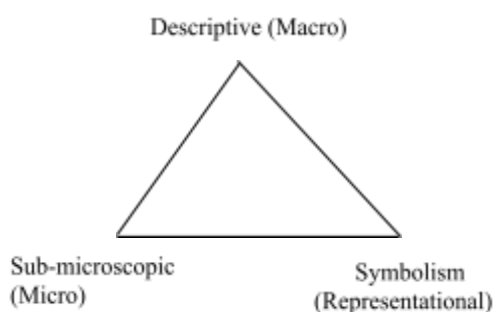


Figure 1: The Chemistry Triangle

The macro level represents what can be seen, touched and smelled while the sub-micro level comprises of the atoms, molecules, ions, electrons and others [2]. Finally, the symbolic or representational level; which comprise of the symbols, formulae, equations, mathematical manipulations and graphs. However, molecules, ions, atoms and the bonds which hold them together are components of the submicroscopic models used by chemists as the main theoretical basis for explanations in the subject. They are invisible objects and cannot be seen with the physical eyes [2]. Therefore, students need a better understanding of the three levels of chemical phenomenon, as difficulty in one level may influence understanding of the other levels. Dramatizing chemical bonding involves the use of human actions to demonstrate interactions between atoms, molecules and ions which occur at the invisible micro level of the chemical phenomena and relate same to the occurrence in the visible macro level of chemical phenomenon. Drama, though not widely utilized as a teaching strategy for science concepts has been found to be very useful in science teaching and learning, mostly the abstract ones which students mostly consider as difficult topics because of the associated difficulty in understanding. Drama is a creative activity performed with the personal experiences of individuals [3]. It has distinctive features and [5] outlined four major feature of science drama as shown below:

1. Facilitated by a teacher, a teaching artist, or other facilitators.
2. aim at academic and/or psychosocial outcomes for the participating students.
3. Focus on process-oriented and reflective experiences.
4. Draw on a broad range of applied theatrical strategies.

Drama has many applications in science teaching and learning. It can be used to enhance students' understandings of scientific concepts as well as an effective assessment tool in the place of written test which is usually associated with anxiety [4]. Teaching science with drama encourages active participation of students in classroom activities, facilitate meaningful learning, improve understanding of science concepts, sharpen appealing experience in chemistry and provoke positive attitudes of students toward the subject [6] [7]. Furthermore, the use of drama promotes student's conversation in language of chemistry; arouse their interest and makes learning process to be "fun" and "stress-free". Learners are

excited as they act or watched drama in a relaxed atmosphere and relate scenes to the concept in consideration. There are different systems of classification of drama in science based on individual perspective [8]. For instance, [9], classified drama into three types based on dimension of science, theme and scripts which are further sub-classified into different categories as shown in the figure below

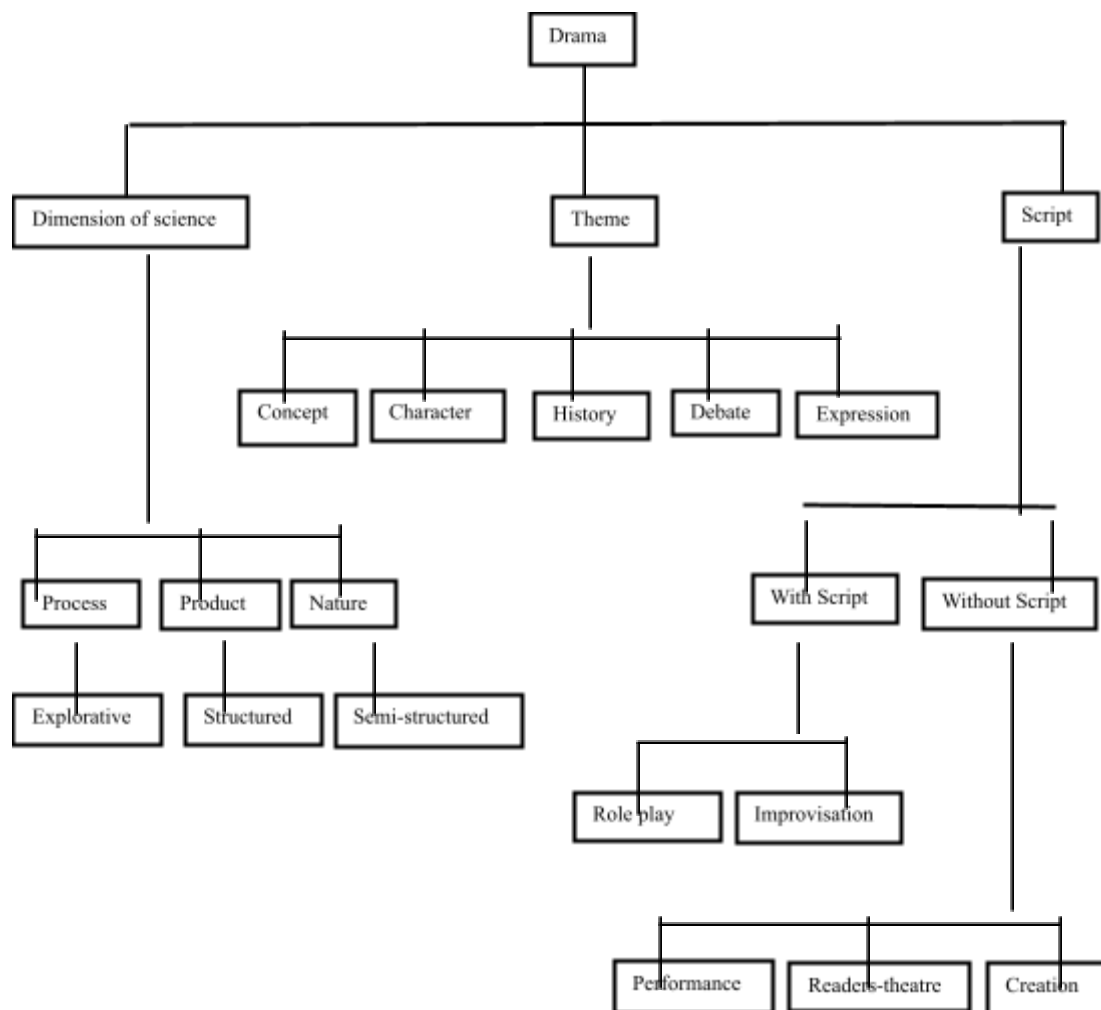


Figure 1.1: Classification of science drama

Misconceptions according to [10] is defined as a mismatch of understanding the concept as formulated by scientists in a given field of study. To [11], misconceptions are student's conceptual and propositional knowledge that is inconsistent with or different from commonly accepted scientific consensus and is unable to adequately explain observable scientific phenomenon. Misconception describes a misstep in knowledge that the learner possesses that is incorrect from the expert perspective of a concept. Such inappropriate concepts can be stored in the learners' memory for long periods of time and may even be

transmitted in the future [12]. Scientific misconceptions therefore, are commonly held beliefs about science, that have no basis in actual scientific facts. It can also be preconceived notions based on religious and/or cultural influences [2]. Misconceptions are well-embedded in students' cognitive structure and are very resistant to change. Therefore, it constitutes a problem to teaching and learning of sciences by hindering assimilation and accommodation of knowledge. Furthermore, it provide a barrier to students' conceptual understanding and usually interfere with concepts presented by the teacher preventing proper understanding [13] [14].

It is widely acknowledged that learner's misconceptions can originate from different sources. Nevertheless, the way science concepts are taught constitute pedagogic learning impediments [2]. The order in which concepts are presented by teachers and even textbooks could serve as a potential source of misconception. Moreover, teachers with poor knowledge base hold several misconceptions about scientific concepts and transfer same to students during lesson. To ensure meaningful learning of science concepts, students' misconceptions must be challenged first, after which they are guided by the teacher to construct "new ideas" which are consistent with "scientifically acceptable" ideas [2]. Accordingly, learning occurs when the learner actively constructs new knowledge by changing existing conceptions, adding new knowledge to what already exist or replacing the preconceived idea they bring to the learning environment with scientifically acceptable ideas [15] [16] .

Available studies on the use of drama as a teaching strategy in science focused on academic performance of students. [6], investigated the effect of learning chemical reactions, more specifically, light and photosynthesis with and without drama. The sample comprised 180 10th grade (boys and girls) students in Israeli middle schools. Findings showed students who learned using drama had better scores than students who were taught without drama. In addition, those students who learned using drama were found to have higher motivation to learn chemistry. [3] evaluated the effect of drama on teaching electrolysis of water to middle school students using randomized pre-test and post-test control group design. The sample comprised of 40 seventh grade students in a private school in Turkey. Results showed that, students in the drama group performed better than those in the conventional lecture method group. Students in drama group were able to integrate theory and practice as they conceived and visualize the abstract concepts in their minds more clearly while acting and watching different scenes in the drama.

[7] investigated the effect of drama-based science teaching on students' understanding of scientific concepts and their attitudes towards science learning. The sample was 87 seventh (7th) grade students from a public male school in Amman-Jordan. The instruments were "Scientific Concepts Test" (SCT) and "Attitudes towards Science Learning Scale" (ATSLS). Results showed that there were statistically significant differences between the study groups in favour of students in the experimental group on both study variables. There was no interaction between the teaching method and the students' achievement level in science. The study recommends employing drama in teaching science.

[17] investigated the effect of drama on the achievement and attitude towards science of a group of upper primary school science students in Trinidad and Tobago. The study adopted pre-test post-test experimental design and the instruments were "Summative Achievement Test" (SAT) and "Science Attitude Test" (ATS). Results showed a statistically significant difference between the mean scores of both groups in respect of achievement levels for the unit of work. Mean ranked scores for attitudes towards science also showed a statistically significant difference in favor of the experimental group. After treatment however, students in the experimental group demonstrated a higher mean score of achievement than the control group. Although the achievement scores of both groups increased after the treatment, the experimental group had a higher improvement.

[18] explored the inclusion of creative drama into science teaching as an instructional strategy for enhancing elementary school students' understanding of scientific concepts. A treatment group of sixth grade students was taught a "Full Option Science System" (FOSS) science unit on mixtures and solutions

with the addition of creative drama while a control group was taught using only the FOSS teaching protocol. Findings of the study showed that students who studied science through creative drama exhibited a greater understanding of scientific content of the lessons and preferred learning science through creative drama. Students in the experimental group stated that they enjoyed participating in the activities with their friends and that the creative drama helped them to better understand abstract scientific concepts. Observations revealed that creative drama created a positive classroom environment, improved social interactions and self-esteem, that all students enjoyed creative drama.

[19] investigated the impact of drama technique on academic success of students and performance on the subject of static electricity for seventh class primary school science and technology students. Quasi-experimental design was adopted specifically a pretest-posttest control group experimental design. The study sample comprised 44 seventh grade students from an elementary school in the district of Erzurum Dadaskent of Turkey. The instrument was a 25 item multiple choice achievement test. Results of the study showed that using the technique of drama had a positive impact on academic success and retention of learning for students. While there was no significant difference between the pretest scores of the study and control groups, the 4-week study period resulted in a significant improvement of the performance of the study group. This confirms that using the drama method in class led to an increase in the academic performance of the study group students

[20] investigated the effect of creative drama-based instruction on fifth graders' science achievements in the light and sound unit and scientific process skills. Quasi-experimental research design was adopted and the sample comprised of 227 5th grade school students in Turkey. The instruments were science achievement test (SAT) and a scientific process skill test (SPST). Findings of the study showed a statistically significant difference between achievement and scientific process skills of students in experimental group where creative drama education had been applied and the control group taught through teacher-centered instruction in favor of the experimental group. Students in the experimental group showed a higher mean score for achievement than those of the control groups. Also, achievement scores of two groups increased after the treatment, the experimental group had higher improvement than the control group. There were significant differences in the means of creative drama applications, science achievement and scientific process skills.

[21] used concept mapping to remediate chemistry teacher trainees' understanding of chemical phenomenon. The sample comprised of 29 first year chemistry teacher trainees of University of Education Winneba in Ghana. Concept map was used as a conceptual change tool to uncover the knowledge structure of teacher trainees before (pre-map) and after they had gone through the treatment period (post-map). The pre-test and post-test intervention concept maps were constructed by trainees to enable the researchers identify new conceptions gained by them after the treatment period. Results of the study showed that students' level of conception improved after the concept mapping intervention. Findings of the study further revealed that concept mapping was useful in remediating chemistry teachers' trainee understanding of chemical phenomenon and revealed differences in conceptual frameworks between trainees with high and low levels of content knowledge. Increase in the percentages of trainees who gave correct responses in the post mapping was also recorded because their content knowledge and skills for constructing concept maps were heightened during the treatment which enabled them to use more understandable concept to form valid prepositions. There was however, an apparent lack of knowledge about metallic bonding which was quite strange and will require further remediation. The finding further showed the importance of using diagnostic tools, especially concept mapping, to enable trainees to relate current concept to explain chemical phenomenon.

1.2 Statement of the Problem

Lecture method of teaching has been widely criticized of encouraging students to construct erroneous ideas which are different from scientific ideas otherwise called misconceptions which hinder students'

understanding of concepts and pose a serious threat to science teaching and learning. This has been a subject of concern to stakeholders that bequeaths researchers with the task of providing alternative strategies that can effectively correct these misconceptions and foster proper understanding of scientific concepts by students. Available studies on drama teaching strategy seem to have focused on students' academic performance without considering their misconceptions. It therefore becomes imperative to find the implication of using drama strategy on students' misconceptions.

1.4 Research Questions

1. What is the extent of misconceptions for students taught chemical bonding using drama strategy and those with lecture 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 strategy in Senior Secondary Schools in Rivers State?

1.5 Hypotheses

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

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

2 Methodology

Mixed method design, specifically, exploratory mixed method design which combines qualitative and quantitative approaches in a single or multiphase study was adopted. This design improves validity of results and provides stronger evidence for drawing conclusion through collaboration of findings from qualitative and quantitative data [22]. The sample comprised 174 SS2 chemistry students in Rivers State public schools and the instruments were a four-tier Chemical Bonding Misconception Diagnostic test and interview schedule. The reliability coefficient of the test calculated by test-retest method was 0.98 while the reliability coefficient of interview schedule was ascertained by careful piloting of the instrument and avoiding discussion during interview session. Percentages and graphs were used to answer research questions while hypotheses were tested at 0.05 level of significance using analysis of covariance. Triangulation of results of quantitative and qualitative data was carried out to draw valid conclusion.

3. Results

3.1 Research Question 1

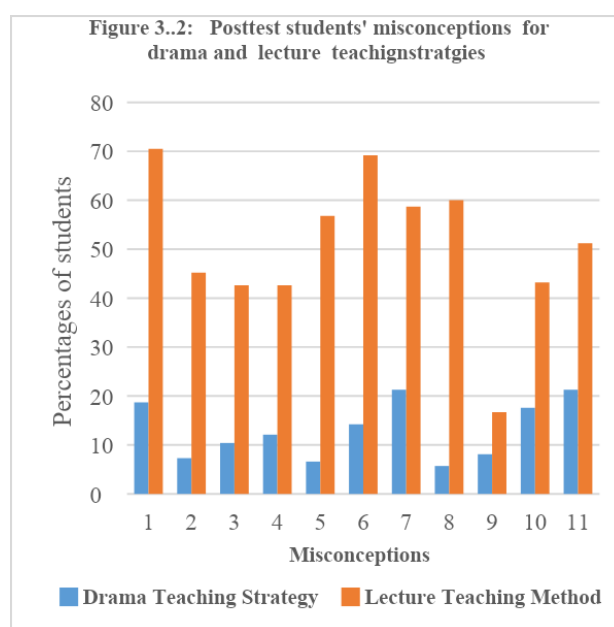
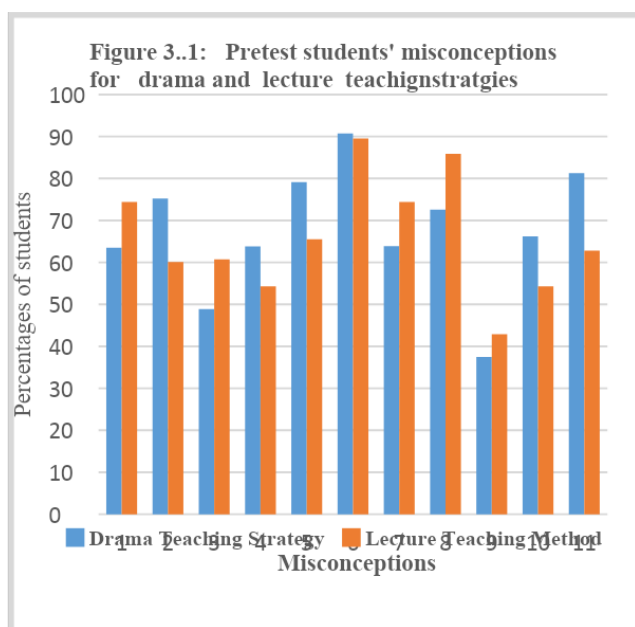
What is the extent of misconceptions for students taught chemical bonding using drama strategy and those taught with lecture method in Senior Secondary Schools in Rivers State?

Table 3.1: Pretest and posttest misconceptions of students taught chemical bonding using drama strategy and those taught with lecture method in Percentages

S/n	Item	Pretest		Posttest	
		DTS	LTM	DTS	LTM
1	All chemical bonding involves transfer or sharing of electron(s)	63.5	74.4	18.7	70.5
2	Atoms with incomplete electron in their outermost shell only undergo chemical bonding	75.2	60.1	7.3	45.2
3	Chemical bond is just an ordinary force that holds atoms together	48.9	60.7	10.4	42.6

4	There are only two types of chemical bonding - covalent and electrovalent	63.8	54.3	12.1	42.6
5	Coordinate covalent bond and Vander Waals are strong forces of attraction	79.1	65.5	6.6	56.8
6	Covalent bond is the shared pair of electrons contributed by the two atoms	90.7	89.5	14.2	69.2
7	Covalent bonding is formed between atoms of group 1 & 2 elements	63.9	74.4	21.3	58.7
8	Electrovalent bonding is formed between atoms of group 6 & 7 elements	72.6	85.9	5.7	60.0
9	The properties of covalent and dative compounds are usually different	37.5	42.9	8.1	16.7
10	Hydrogen bonding does not affect the properties of the compound	66.2	54.3	17.6	43.2
11	Electrovalent bond is the only is bond that electrostatic in nature	81.3	62.8	21.3	51.2

DTS =Drama Teaching Strategy, LTM = Lecture Teaching Method.



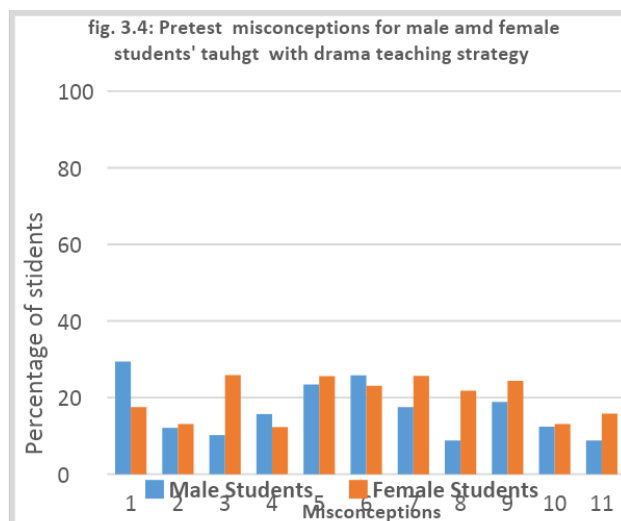
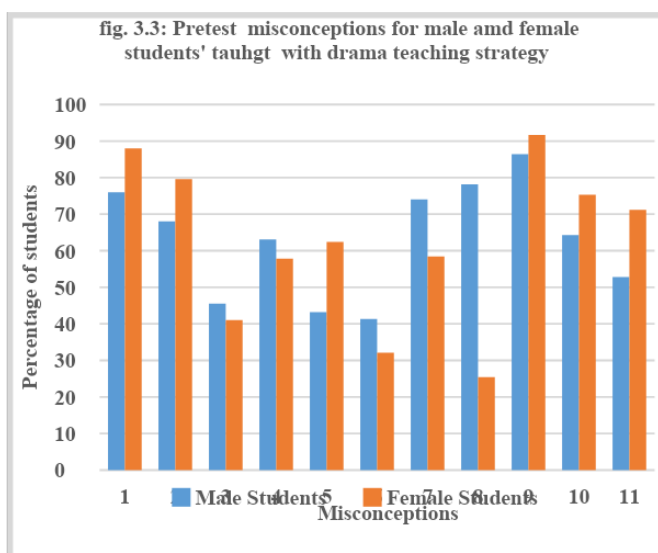
From Table 3.1 and figures 3.1 and 3.2, before treatment, students taught chemical bonding using drama strategy (experimental group) and those taught with lecture method (control) held various misconceptions to a very high extent (90.7% - 37.2%) and (89.5% - 42.9%) respectively. After treatment, there was remarkable reduction in the high extents of misconceptions for students taught chemical bonding using drama strategy to very low extent (21.3% - 5.7%) while those of the students taught with lecture method persisted to a high extent (70.5% - 42.6%) except misconception 9 with low extent of 16.7%.

3.2 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 3.2: Percentages of misconceptions of male and female students taught chemical bonding using drama teaching strategy

S/N	Misconceptions	Pretest		Posttest	
		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(s) 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 compound	64.3	75.3	12.4	13.1
11	Electrovalent bond is the only is bond that electrostatic in nature	52.8	71.2	8.8	15.8



From Table 3.2 and figures 3.3 & 3.4, 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, 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.

3.3 Hypothesis 1

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

Table 3.3: Analysis of Covariance (ANCOVA) of the mean misconceptions of students taught chemical bonding using drama teaching strategy and those taught with lecture method.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	19401.371	2	9700.685	89.911	.000
Intercept	3625.424	1	3625.424	33.602	.000
Pretest	6294.880	1	6294.880	58.345	.000
Treatment	7527.102	1	7527.102	69.765	.000
Error	12515.419	116	107.892		
Total	489973.000	119			
Corrected Total	31916.790	118			

Table 3.3 shows that $F_{1, 116} = 69.65$, $P < .05$, the null hypothesis which states that there is no significant difference between the mean misconceptions of students taught chemical bonding using drama strategy and those taught with lecture method in Senior Secondary Schools in Rivers State is rejected. This infers that there is a significant difference between the mean misconceptions of students taught chemical bonding using drama strategy and those taught with lecture method in Senior Secondary Schools in Rivers State.

3.4 Hypothesis 2

HO₄: There is no 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.

Table 3.4: 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			

Table 3.4 shows that $F_{1, 171} = 18.888$, $P < .05$. 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 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.

3.5 Pretest Interview Results

Conception 3

- | | | |
|--------------|---|---|
| Researcher1 | - | 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 |
| Researcher2 | - | 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 combining 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” refer 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 holds 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.

3.6 Posttest 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 |
| Researcher 2 | - | 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

4. Discussion of Results

The convergence of results of diagnostic test and interview schedule revealed a remarkable reduction in high extents of misconceptions for students taught chemical bonding using drama strategy while those of the students taught with lecture method persisted at high extent (Tables 3.1, Figures 3.1 & 3.2).

This suggests that students' misconceptions were corrected on application of drama strategy while there was no effect on the use of lecture method of teaching. This finding agrees with that of [17] where students' alternative conceptions of teacher trainees in University of Winneba Ghana were corrected and the trainees developed a more scientific reasoning when asked similar questions that had been asked before interventions after treatment.

The observed change in students' conceptions on application of drama strategy could possibly be attributed to the fact that, there was exchange of ideas in the drama classroom environment which encouraged collaboration of ideas and social interaction as students took active participation in all task through drama acting and watching. Also, their interests were aroused as they enjoyed the drama and relate scenes to concept of chemical bonding in a relaxed atmosphere. This makes the process of learning fun, interesting, stress-free and motivates students to learn with proper understanding. Through this process, students were actively involved in the process of making meaning and knowledge construction which enhanced permanent storage of information in the long-term memory and easy retrieval of such information. This is in support of the assertion of [23] that learning occurs when students' existing ideas are changed. It further validates the claims of [3] that use of drama in teaching scientific concepts, mostly the abstract ones provide students the opportunity to make their understanding concrete and personal rather than transmitting knowledge from the teacher or textbooks to students.

On the other hand, the persistence of the high extents of students' misconceptions on application of lecture teaching method is an indication that students maintained their personal ideas which suggests lack of change in conception possibly due to the fact that activities in the classroom were dominated by the teacher while the students played passive role as listeners that cannot question authority of the teachers who is believed to be the "ultimate source and dispenser of knowledge". There was no collaboration of knowledge as students learnt individually which makes the learning process boring and cumbersome.

Further evidence showed that before treatment, male and female students taught chemical bonding using drama strategy held misconceptions to a very high extent. After treatment, 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 (Table 3.2 and figures 3.3 & 3.4). Further findings revealed a significant difference in the misconceptions of students taught chemical bonding using drama strategy and those taught with lecture method (Table 3.3). This finding is consistent with that of [3], [7], [17], [18], [19] and [20] where students taught using drama teaching strategy performed significantly better in achievement test than those taught with conventional lecture method. This infers that, drama is an effective teaching strategy for correcting students' misconceptions about chemical bonding than lecture method. Also, there was significant difference in misconceptions of male and female students taught chemical bonding with drama strategy (Table 3.4).

5. Conclusion

Drama teaching strategy is effective in correcting student's misconceptions about chemical bonding and related concepts in science.

6. Recommendations

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

1. Teachers should adopt concept drama teaching strategy in teaching abstract concepts in chemistry such as bonding among others.
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 change in conception by constructing scientifically acceptable knowledge from preconceived ideas.

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