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Remedying Students' Misconceptions in Learning of Chemical Bonding and Spontaneity through Intervention Discussion Learning Model (IDLM)

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***Abstract*—**In the past few decades, the field of chemistry education has grown tremendously and researches indicated that after traditional chemistry instruction students often lacked deep conceptual understanding and failed to integrate their ideas into coherent conceptual framework. For several concepts in chemistry, students at all levels have demonstrated difficulty in changing their initial perceptions. Their perceptions are most often wrong and don't agree with correct scientific concepts. This study explored the effectiveness of intervention discussion sections for a college general chemistry course designed to apply research on students preconceptions, knowledge integration and student explanation. Three interventions discussions lasting three hours on bond energy and spontaneity were done tested and intervention (treatment) students' performances were compared with that of control group which did not use the experimental pedagogy. Results indicated that this instruction which was capable of identifying students' misconceptions, initial conceptions and integrating those ideas into class discussion led to enhanced conceptual understanding and better achievement for the experimental group.

***Keywords*—**Intervention Discussion Learning Model, Learning, Remedying, Students' misconceptions.

I. Introduction

CHEMICAL thermodynamics is one of the more difficult concepts in chemistry owing to its abstract character and its demanding the mastery of a large number of subordinate concepts. Students conceptions in thermodynamics, in particular have been the topic of many studies There is a wealth of literature on the difficulties students encounter with the energetic of chemical bonding in high school [1], [2] and in colleges [3], [4] as well as through advanced courses in colleges [5], [6]. These literatures provide ample evidences that students have fundamental misunderstanding of these areas and that often those misunderstanding; persist after traditional methods of teaching. Traditional methods may have significant effect on students' misconceptions but are far from being sufficient in remedying student's misconceptions that are persistent and highly resistant to change [7].

An understanding of bonding and thermodynamics is essential in chemistry a science which undertakes the study of matter and its transformations. A chemical reaction takes place and reactants are converted into products. Chemical bonds are broken and formed. Energy is required to break bonds in the reactant and energy is released upon the "formation of new product bonds. Reactions that release energy are often characterized by the breaking of weak bonds and the formation of stronger bonds in the products. The bond energy for a specific chemical bond is defined as" the energy required to break that chemical bond' Equivalent energy is released upon formation of new bond. Within these deceptively simple definition rest the difficulty with understanding bond breaking and formation, Student have trouble remembering and applying these definitions in appropriate situations.

The ability to predict whether certain reactions will occur or not i.e. whether they will be spontaneous or not lies the power of thermodynamics in chemistry. The change in free energy can easily be calculated from the change in enthalpy ΔH, the change in entropy ΔS and the temperature T according to:$\Delta G = \Delta H - T\Delta S$. Students are very proficient in manipulating the above equation in solving standard algorithmic problems. Where student encounter difficulty is in answering qualitative questions about spontaneity when no numbers are given for quantities, students are reluctant to speculate about whether a reaction will occur or not and when they do, misconceptions are abound [3].

Numerous studies have identified misconceptions that students posses about thermodynamics. Misconception refers to students misunderstanding, ideas that do not agree with accepted scientific views. Various other terms are used for misconception, such as preconceptions, alternative conceptions, alternative framework and students deceptive and explanation system [8], [9].

The studies on misconceptions in thermodynamics identify the problems student have with chemical bonding and spontaneity as well as pinpoint common misconceptions for these topics. What research literature does not adequately provide are pedagogies designed to target these specific known misconception in college chemistry.

II. Purpose of the Study

The aim of this work was to identify the various misconceptions college of education students hold about bond energy and spontaneity and apply a conceptual change strategy (intervention discussion leaning model) to remedy the misconceptions and improve achievement.

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III. Research Questions

1. What fundamental misconceptions do college of education students hold about the concept of bonding and spontaneity?
2. What percentage of the students would possess each of identified misconceptions?
3. To what extent will the application of IDLM reduce the incident of student misconceptions in bonding and spontaneity and enhance their achievement?

IV. Methodology

The study used pre-test-post-test quasi experimental research design. The population of the study includes all final year students of all the three colleges of education in Kano state of Nigeria, but the scope was delimited to eighty final year NCE students of both sexes from the 3 colleges of education.

The eighty students in the sample were chosen to reflect the three level of achievement (above average, average and below average) based on the pre-test and previous class performances. The sample was split into two groups: experimental and control. The experimental group though one group split into two sub groups i and ii with two instructors but the same treatment. This was to ensure proper treatment because of the nature of the model: intervention discussion which requires enough time. All the students in the sample enrolled for the chemistry programme of the National Commission for College of Education (NCCE) and registered for CHE 324 chemical thermodynamics, after completing two pre-requisites courses namely CHE 321 chemical equilibrium and CHE 221 (chemical kinetics). These three courses make up what is referred to in this study as general chemistry.

Two instruments namely General chemistry misconception test (GCMT) and general chemistry achievement test (GCAT) were used for data collection GCMT: The purpose of GCMT was to assess student's misconceptions/ preconception about the selected concepts. It is a diagnostic test in which wrong answers are more informative than correct answers. The test consist of fifteen multiple choice items, the second part of each item is a blank space provided for explanation of student reasoning. This is meant to expose clearly their misconceptions/ preconception GCAT. This was meant to access student conceptual as well as quantitative understanding (achievement) in the concepts chosen. The test contained 15 multiple choice questions.

The two instruments were given to three (3) experienced lecturers who have taught general chemistry at the undergraduate level or NCE levels to examine them for coverage, clarity or ambiguity, relevance and to the level of the student and based on the research questions. Any item agreed upon by 2 out of the 3 lecturers to meet the above stated criteria was retained while any item 2 of the 3 lecturers rejected as not meeting the condition as stated was dropped. Any item 2 out of the 3 advised to be modified or corrected was also reflected as advised.

The reliability of the two instruments GCMT and GCAT were estimated by calculating their split-half reliability coefficient corrected by the application of spearman - Brown prophecy formula. The reliability coefficients were 0.75 and 0.70 respectively.

V. Training of Research Assistants (Instructors)

Three assistants were recruited for this work. All the three research assistants are lecturers with M.Sc. degree in Chemistry, Postgraduate Diploma in Education and had over ten years of teaching experience. They have interest in chemical education research. The research assistants were trained and randomly assigned to the experimental group and control group.

The research assistants were trained for one week of three sessions by the author to standardize the administrative procedures and the implementation of the treatment. A training manual prepared by the author was used for the purpose of training.

VI. Experimental Procedure

This research was conducted in second semester of 2007/2008 session of the chemistry programme of the colleges of education used. Student attended two hour lecture per week and one 3-4 hours discussion/Lab section 3 - two hour discussion sections were done for the experimental group using worksheet where the selected concepts were covered using the pedagogy and the material (worksheet). The intervention discussion learning model took the following steps.

i) Every student was given the opportunity to identify his or her idea or thought
ii) The initial ideas were written down on a paper of every student after they are given few minutes to think about their own ideas
iii) Student ideas were clarified through discussions in small groups of 4–5 students and then the whole class discussion.

The roles of the instructors were to write all the ideas of student after restating them on the blackboard ask for student responses to those ideas mentioned which ensured discussion about the ideas.

They guided the class discussion, clarified student ideas introduced challenging contradicting information when students struggled with misconception but gave no firm answers.

The control group was taught by an instructor using the traditional methods but not the intervention technique. Both the control group and experimental group covered the same topics.

The two pre-tests and two post-tests were administered by the research assistance at the beginning and end of the discussion sections. The results were collated, analyzed and presented in Tables I-III.

TABLE I
IDENTIFIED STUDENT MISCONCEPTIONS IN (BOND ENERGY SPONTANEITY) IN PERCENTAGES

S/N	BE and spontaneity	Before Treatment			After Treatment			Reduction Rate	
		E	C	T	E	C	T	E	C
1	Bond store energy which is released when the a bond breaks	25	15	40	8	14	22	68	6
2	Energy can either be absorbed or released when chemical bonds break	24	18	42	10	13	23	58	28
3	Reactions are likely to occur at high temperature whether the reaction is exothermic or endothermic	41	39	80	9	16	25	78	39
4	Exothermic reactions are always spontaneous	38	45	83	18	28	46	53	38
5	Endothermic reactions cannot be spontaneous	43	35	78	20	24	44	53	31

E = Experimental group; C = Control group; T = Total.

$$\text{Reduction rate of misconception}=\frac{mbt-mat}{mbt}\times\frac{100}{1}$$

where mbt = misconception before treatment; mat = misconception after treatment.

TABLE II
THE STUDENT SCORE OF THE MISCONCEPTION TEST AND STANDARD DEVIATIONS OF EXPERIMENTAL GROUP AND CONTROL IN THERMODYNAMIC, EQUILIBRIUM AND KINETICS CONCEPTION

Group	N	Mean Pre-Test	Mean Post-Test	Mean Diff.	SD Pre-Test	SU Post-Test
Experimental Group	40	29.325	47.13	17.80	5.66	5.30
Control group	40	26.78	31.75	4.97	2.98	4.36

TABLE III
THE MEAN ACHIEVEMENT SCORES AND STANDARD DEVIATIONS OF EXPERIMENTAL GROUP AND CONTROL GROUP

Group	N	Mean Pre-Test	Mean Post-Test	Mean Diff.	SD Pre-Test	SU Post-Test
Experimental Group	40	27.60	43.20	15.60	3.67	6.59
Control group	40	25.67	34.73	9.06	5.98	4.40

VII. RESULTS

Table I gives detail of the various misconceptions held by college of education students as well as the percentages of each of the misconceptions identified before and after the application of the intervention discussion learning model.

There are five (5) misconceptions identified about bond energy and spontaneity in the study (see Table I) before the treatment of .the experimental groups, the student in both the control and experimental groups possessed each of these misconception at relatively high percentages ranging between 42% - 80% (Table I). After the treatment of the experimental groups using the conceptual change strategy, (IDLM) the misconceptions of the experimental groups were drastically reduced while those of the control groups were very minimal in the reduction rate (Table I).

The data in Table II show that the misconception pre-test, and post test scores of the experimental group were 29.33 and 47.13 with the standard deviations of 5.66 and 5.30 respectively. The mean difference was 17.80. The pre-test and post-test scores of the control group were 26.78 and 31.75 with the standard deviations of 3.42 and 8.72 respectively. The means difference was 4.97.

The table revealed that the experimental group has a higher post-test score and a higher mean difference (17.80) than that of the control group (4.97). The experimental group has more spread (5.66) in both the pre-test score post-test score of (5.30) than that of the control group (2.98 and 4.36) respectively. From the data in Table II the application of intervention discussion learning model could be said to have a positive influence on the experimental group with a higher mean difference than the mean difference for the control group.

From Table III experimental group has a higher mean pre-test score (27.60) and a higher mean post-test score of (43.20) than the control group with pre-test score of (25.67) and post-test score of (34.73). The experimental group mean post score standard deviation (6.5) spread more than that of control group while control group pre-test mean score standard deviation (5.98) spread more than the experimental group pre-mean score standard deviation (3.67). The achievement mean difference of the experimental group (15.60) is higher than that of control group (9.06). Hence the intervention discussion learning model had a positive influence on the experimental group with a better achievement.

VIII. DISCUSSIONS

When students' written answers were analysed, incorrect response to questions clearly brought out the misconception that are common. For instance calculating enthalpy change from bond enthalpies the students lacked better understanding of how to use bond enthalpies in problem solving. This explanation is consistent with other studies showing that student do not perform better on quantitative problems when lacking conceptual understanding [10] [11]. There was incorrect use of equation by students which showed that they were blindly applying equations and not thinking about the information given [4]. The performance on the quantitative question suggested that student did not understand and could not apply the concept of bond energy.

Spontaneity (Gibbs free energy change), this was tested thoroughly with both quantitative and qualitative questions. Students were expected to use thought process to answer questions to determine the sign of the entropy and enthalpy changes for the reactions for example using chemical equation and $\Delta G= \Delta H-T\Delta S$ one can determine the sign of both entropy (ΔS) and the enthalpy change (ΔH). The reaction that forms two gases to give a solid product is a clear decrease in disorder so the entropy change is negative, for the reaction to favour the product it must be exothermic, a negative enthalpy. The students indicated lack of understanding: Many indicated that every reaction with positive free energy had positive entropy and negative enthalpy, this demonstrated no appreciation for the competition between entropy and enthalpy and assume they are both favoured if products are favoured. The findings are in line with that recorded by [3], and a group at Toronto

University [7], where over 48% of the students demonstrated such lack of deep conceptual understanding. They regarded them as taught misconception reinforced by repetition and by illustration in textbooks. This lack of deep conceptual understanding that is, misconceptions are used by the students for explaining observations and would become self-reinforcing [4].

The experimental groups having higher mean gain scores in both misconception and achievement tests, were expected because studies have shown that students do not learn as effectively and deeply when they receive explanation as when they give explanation [4]. This finding is in agreement with report from a review of same age (peer tutoring) by [10] who observed that student ability to learn a task correlates with their instructional competence and their peer's learning.

IX. Conclusion

Based on the finding of this work the following conclusions were made.

- College of education student possess a variety of misconceptions about bond energy and spontaneity
- The percentage of the student possessing the misconceptions range between 40% and 80% which could be said to be relatively very high,
- The application of intervention discussion learning model offered a very good conceptual change strategy for reduction of misconceptions and ensured deep conceptual and meaningful understanding of chemistry concepts.

X. Recommendations

- Students come into the classroom with a conceptual framework already present from everyday experience and from previous formal and informal education. Teachers of chemistry should endeavour to identify these preconceptions which may not be scientifically right, correct and integrate with the new material being covered in the class.
- Students should be encouraged to express, explain and elaborate their positions to themselves.

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