## Research Article

# ACTIVE LEARNING OF CHEMICAL BONDS WITH GENDER RESPONSIVE INSTRUCTIONAL METHOD IN THE COLLEGE CHEMISTRY

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## ABSTRACT

Multimodal Instructional Method (MIM)  has been successful used as an effective gender responsive instructional method for actively learning of chemical bonding in Chemistry by both male and female science teacher trainees in the College. Learning of chemical bonding and the mode of instruction are not only one of the most identified concepts that posed difficulty for students to learn, but scare most of the students especially female students to study science. This paper examine the effectiveness of the use of Multimodal instructional Method to teach chemical bonding and the effect on learning needs female and male students. The results of 60 college students which comprised of 30 female and 30 male students confirmed that the method created active learning for every student.The MIM improved deeper conceptual understanding of chemical bonding, catered for differences learning styles of both male and female. Most importantly, the method made female students developed interest to study the subject, and also motivated them to become science teachers.

## INTRODUCTION

The study of chemistry has over the years in Ghana appeared to be unpopular among female group compared to their male counterparts in very levels of education. Girls' participation in Science subjects both in secondary schools and colleges of education is still lower than that of boys. For instance it reported in the first Science, Technology, Engineering, and Mathematics (STEM) clinic organized in December 2016 in Jasikan District in the Volta region by UNESCO, in collaboration with the Girls' Education Unit of Ghana Education Service, stated that only 29 girls were reading pure science that comprise of Chemistry, Biology and Physics out of 855 girls in Senior High School. There are many factors that had influenced girls studying science, including the methods of teaching science subjects and the false belief among girls that science subjects are suitable for boys. The reported factors that contributed to a few females studying science as their major area are socio-cultural variables, public views of science as male profession, strategies of instruction during science lessons, and school environment (Barnea & Dori, 1999; Tobin & McRobbie, 1997). One major factor facing science education

is the identification of the most effective and efficient pedagogy for learning chemistry concepts by students, whether male or female (Bennett, 2011). It is argued that effective learning depends on the teaching approaches used to teach a concept (Celik and Pekta 2017; Trigwell, Prosser and waterhouse, 1999). Classroom instructions  or teaching methods that are to be used to teach Chemistry concepts therefore need to focus on toward the interest, needs and value of every student, whether boy or girl, for effective learning to take place. This removes the fear that the subject is a difficult discipline.

At the Colleges of Education level, the courses for studying science programme is designed such that the teacher trainees would acquire the relevant content knowledge and methodology competencies with respect to Basic School science teaching. Unfortunately, few female students choose to study or participate in the science programmes. This has resulted to less number of female science teachers who could have being role models to girls at the basic schools, compared to male teachers. There for factors that lead to having females

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participating in sciences or influence girl-child interest of becoming science teacher need to be examined.

Chemical bonding concepts in the chemistry aspect of Integrated Science have been a major problem for most students especially females. It is also one of the reported concepts in science literacy which learners always have difficulty in learning (Coll&Treagust, 2000; Sitalakshmi, 2008). The students have difficulties of interpreting and comprehending literature on bonding of atoms, as expected by chemistry community, which could affect their interest in science literacy. The use of different multiple modes of representation and instructional approaches on the same text have been found to be significant in development of science literacy (Bennett, 2011). These approaches of teaching represent content knowledge in a way that interlocks with different learning styles that appealed to different learning preferences. Using the Myers-Briggs Type Indicator for instance, Nuby and Oxford (1996) found some significant difference in learning preferences. From this African American male and female students indicated a strong preference for using different dimensions of instructions to teach a concept. Gender differences in learning style preferences have a linkage with learning modes preferences in visual, read-write, and kinaesthetic (Wehrwein, Lujan and DiCarlo (2007). The finding from Wehrwein, Lujan and DiCarlo indicated that most male students preferred multimodal instruction, specifically four modes, whereas most female students preferred single mode instruction, in particular. Some study also have suggested that more males showed preference for applied learning instruction that involves using of everyday life experience as a basis for learning, while females prefer more abstract by reading assignments, organized learning materials and instructors' knowledge (Keri, 2002). According to reports male students prefer learning style with no visual modes while females are distributed across multimodal learning styles (Sankey, Birch & Gardiner, 2010; Lau & Yuen, 2010). However, in terms of what stimulus learning by students, differences of learning styles are socially constructed in the in the classroom (Milgram, 2009 cited in Lau & Yuen, 2010). For Hyde (2005), the males and females are similar in learning science but different in most psychological variables including mathematical ability. That is to say, the observable difference between males and females are not innate (Lau & Yuen, 2010). Therefore it is important for educators to use gender friendly instructional methods for both female and male students to actively participate in learning chemistry concepts in class.The study examined impact of multimodal instructional Method (MIM) on the effective learning of chemical bonding in Chemistry by male and female in the College Education.

## Theoretical Framework of the Study

The theoretical framework that informed this study is the transmediation. This is the transfer of information from one symbolic representation system to another (Suhor, 1984). In this framework, a student transfers key concepts and ideas from one text and creates a new text by incorporating those key themes and ideas. It is based on the fact that symbols are mostly used to create meaning in learning chemical bonding. A symbol simply does not stand for something rather its meaning is culturally mediated to understand concepts (Siegel, 1995).

Symbols can be understood by the individual based on his or her experiences with the world. A symbol is simply not a substitution for an object rather it tells something about the meaning of the relationship between the sign and the object, which would therefore require an interpretant (Short, 2004). The use of symbols in different modes enables learners transfer knowledge from one concept to another making science learning an integration of multimodal discourses (Kress, Jewitt, Ogborn, &Tsatsarelis, 2001; Norris & Phillips, 2003; Lemke, 1998, 2004)

## Research Questions

### The study addressed the following research questions

1. What are the differential impacts of multimodal instructional method on male and female students' understanding of chemical bonding?
2. Will the instructional method enhance students' interest of learning chemical bonding in chemistry?
3. What are the implications of findings to developing pedagogical skills in female science teacher?

## Null Hypothesis

There is no significant difference between the mean scores of male and female students who are taught chemical bonding using multimodal instructional method.

## Research Design

The study used a pretest-posttest with control group design. The participants were assigned to two groups, a control group (Males students) and an experimental group (female students). This design allowed the two groups of students to be pretested and pot-tested with the same test to evaluate the effects of MIM on the active learning of chemistry concept by students. Five integrated multimodal instructional method was used to instruct the lessons. This method emphasized on the integration of five different modes (methods) of instructions; realia, visual, analogy, symbols and verbal interaction. The lesson included step-by-step procedures beginning from introduction through exploration, explanation and solution, and ending at taking action. The design allows comparison the post-test results between the two groups of students after the treatment, to determine effectiveness of it (Martyn, 2009) considering the strong internal validity.

The sample for the study was 60 first year students of a College of Education in the Oti Region of Ghana. The classes were chosen due to the fact that researcher wanted a fair representation of male students and female students. The male students were randomly selected from each class through index numbers without the student been aware. The study used both quantitative and qualitative data gathering instruments to collect the primary data. These were questionnaire, and Chemical Bonding Concept Test (CBCT). Questionnaire was effective used for getting factual information about opinion, practices and attitudes of a subject(Amedeker, 2000). The validity of the instruments were determined through the judgment from expect which instruments were amended according to their comment and recommendations before being administered. The instruments were pilot tested and the Cronbachs alpha coefficient of internal consistency was used to determine the reliability coefficient of the instrument data

(Barnea 1996).The statistical analysis of the tests (pretest and post-test) was analyzed using SPSS-20. The descriptive statistics such as means, mean difference, standard deviation and t-test computed were used to summarize the general trends in student performance. Inferential statistics was used to identify significant difference within the quantitative data for the purpose of answering the research question. Inferential statistics such as t-test was performed at the 0.50 level with 2 tails. The inferential statistics used in this study was used for answering the quantitative aspect of the research question as well as testing hypotheses stated earlier in the first chapter of the study.

### Treatment

The students were instructed by the same teacher (researcher) on the content. At the beginning, the two groups of students were pretested to determine whether there was any difference between the two groups with respect to their understanding of chemical bonding. The students were instructed by MIM with three steps.The first step, the researcher asked students questions at the beginning of the instruction to activate their prior relevant knowledge and to promote student-centered interaction and agreement. The second step involved the exploration of students' understanding. The students were allowed to discuss the question among themselves in groups using their previous knowledge on bonding. During the discussion, the students realized their own and others' thoughts, shared their ideas, defended their answers and reached a consensus about the question without the interference. The groups constructed their tentative answers freely and submitted a common answer to the researcher. The researcher was informed about the students' previous ideas. Based on the answers, the researcher used multimodal instructional approaches to explain the concepts in step 3. While explaining the concept, the researcher emphasized on students' misconceptions with reasons and presented correct explanation by using multimodal approaches of five different modes of instructions (verbal interaction, symbols manipulation, analogy, diagrams/visual and regalia). Examples were given using analogies, videos, computer animations and diagrams illustrations. This was integrated with the other four modes; Verbal interaction was used when the teacher explained concepts in symbolic, animation and videos. Symbol manipulation was used in this illustration of how bonds are formed through computer animations and chalk board illustrations. Diagrams and Visual; This mode includes graphic, computer animations and video of how electrons are transferred and shared between atoms involved in bonding, were shown to students. The students observed and asked questions to understand where they were not clear. Summary of how MIN was used is as follows;

1. Use verbal interaction and realia to introduce the topic
2. Use symbol manipulation and verbal interaction to illustrate the concept
3. Use verbal interaction, symbolic manipulation and computer animation and video

## RESULTS, FINDINGS AND DISCUSSION

### Results and Findings

CBCT was administered at the beginning to the two groups of students to determine whether there was any difference between them with respect to understanding chemical bonding, after they learnt the concepts through the usual instructional method. When the marks scored by the students (pretest) were analyzed, as shown in Table 1 none of the students from the male or the female side scored marks above 15-20. However 65% of the students scored marks within 0-7, while only 35% of the students scored marks within 8-14. This performance formed the bases that the students in general were having difficulty in learning bonding concepts as suggested by previous researches. When the students were assessed (Posttest) after the MIM of instruction, only 15% of the students scored marks within 8-14 while as much as 85% of the students scored marks within the range of 15-20. No student scored marks within the range of 0-7. The result indicated a significant differences ($p < 0.05$, $p=0.000$, 10.107) mean scores. between the pretest and the post-test $=$

These findings have suggested the improvement of students understanding of chemical bonds concepts after they were instructed by MIM.

**Table 1** Frequency Distribution of Pre-test Score of students

| Marks score | Frequency of Pre-test | Percentage (%) of Pre-test | Frequency of Post-test | Percentage (%) of Post-test | P | Mean Difference |
|---|---|---|---|---|---|---|
| 0-7 | 39 | 65 | - | - | | |
| 8-14 | 21 | 35 | 9 | 15 | 0.000 | 10.107 |
| 15-20 | - | - | 51 | 85 | | |
| Total | 60 | 100 | 60 | 100 | | |

The pretest scores were also analysed according to female and male students' performance (Table 2). The result female students showed that 70% of the female students scored marks within the range of 0-7 while only 30% of them scored marks within 8-14. No female student scored marks from 15- 20 marks range. For the results of male students, 60% of male students scored marks from the range of 0-7 while 40% of them scored marks from 8-14. None of the male students also scored marks in the range of 15-20. The results showed that both females and males did not score higher marks, and many of them the two groups of students scored lower marks.

**Table 2** Frequency and Percentage Distribution of Pre-test Score according to female and male students

| Marks score | Frequency of females | Percentage (%) of females | Frequency of males | Percentage (%) of males |
|---|---|---|---|---|
| 0-7 | 21 | 70 | 18 | 60 |
| 8-14 | 9 | 30 | 12 | 40 |
| 15-20 | - | - | - | - |
| Total | 30 | 100 | 30 | 100 |

The study was to determine whether there was or no significant mean difference between male and female students with respect to understanding chemical bonding concepts when they are taught by MIM. The percentage distribution that showed the number of student of the male and female out of the total number of 60 was investigated as indicated in Table 3. The

results from the analysis showed that the MIM of teaching was effective for both male and female students. There was much difference between the male and female students' performance. Hence their understanding of chemical bonding was mostly the same. From Table 5, none of the students from the male or the female side scored mark below average performance. When 5% male of experimental students scored marks in the average range, 4% of the female students also scored marks in the same range. In the above average range, 25% males of the experimental students scored the marks while 26% females of the experimental students scored the marks in the range.

The posttest scores of female and male students were analysed to determine their performances after they were taught by MIM (Table 3). The results showed that none of the female students and male students scored marks in the range of 0-7. The result female students showed that 13.3% of female students scored marks within the range of 8-14 while as high as 86.7% of them scored marks within 15-20. The results of male students indicated that 16.7% of male students scored marks in the range of 8-14 while 83.3% of them scored marks in the 15-20. The results suggested that there was a great improvement of both females and males scored marks when they were taught with the MIM. It also showed that the two groups of students did not score lower marks but more of them had scored high marks. However, a higher percentage of females scored more marks than the male students.

**Table 3** Frequency and Percentage Distribution of Posttest Score of female and male students

| Marks score | Percentage(%) of Female | Percentage(%) of Male |
|---|---|---|
| 0-7 | - | - |
| 8-14 | 13.3 | 16.7 |
| 15-20 | 86.7 | 83.3 |

### Significant Difference of Gender Mean Scores

The results were further analyzed of both pretest sores and posttest scores between female group and male groups (Table 4). This was conducted to determine the trend of significance level of differences of male and female groups in the pretest and posttest performances. The means scores of male and female groups were 7.800 and 6.233 respectively for the pretest score, which showed a significant difference ($p=0.008$) with the mean difference of 1.567. The result suggested that there was a significant difference between the male students' performance and female students' performance on the understanding of chemical bonding concepts. For the Posttest scores, the means of male and female groups are 16.631 and 17.333 respectively, which indicated no significant difference ($p=0.233$) with the mean different of 0.700 which indicated the higher female students' performance more than male.

**Table 4** Summary Results of Mean Scores and Difference of Post and Pretest scores of the female and male student groups

| | Male mean | Female Mean | P | Mean difference |
|---|---|---|---|---|
| Pretest scores | 7.800 | 6.233 | 0.008 | 1.567 |
| Post-test score | 16 .631 | 17.333 | 0.233 | 0.700 |

### Views of Male and Female Student about MIM

Also the difference in perception and attitudes of the male and female students, Table 5 shows the gender group difference on the students' perception after they were instructed by MIM. The results presented each degree of both male and female perceptions about MIM. Higher number of male students more than female students strongly agree and agree had positive attitudes towards the use of MIM to instruct chemical bonding.

**Table 5** Responses of Male and Female Students about MIA

| | | Strong Agree | Agree | Not sure | Disagree | Strong Disagree |
|---|---|---|---|---|---|---|
| | | Count in percentages (%) | | | | |
| MIMimprove understanding of chemical bonding | Male | 26.7 | 21.7 | 1.7 | - | - |
| | female | 31.7 | 11.7 | 6.7 | - | - |
| MIM motivates learning of the concept | Male | 20.2 | 28.7 | | 1.7 | - |
| | female | 21.3 | 26.6 | 1.8 | 0.3 | - |
| MIM makes me feel comfortable and interested in class to the concept | Male | 31.7 | 13.3 | 5.0 | - | - |
| | female | 38.3 | 11.7 | | - | - |
| Improves my ability to interpret and comprehend the concept | Male | 13.3 | 30.0 | 6.7 | - | - |
| | female | 25.0 | 16.7 | 5.0 | 3.3 | - |
| Learn better when taught only with verbal modal instruction | Male | 1.7 | - | 5.0 | 21.7 | 21.7 |
| | female | - | - | 11.7 | 21.7 | 16.7 |
| Learn better when MIMinvolves Visual, diagrams, charts, videos and PowerPoint animations | Male | 18.7 | 18.3 | 13.3 | - | - |
| | female | 23.3 | 15.0 | 6.7 | 3.3 | 1.7 |
| Five MIM improve understanding and interest in learning chemical bonding. | Male | 8.3 | 36.7 | 5.0 | - | - |
| | female | 13.3 | 28.3 | 3.3 | 3.3 | 1.7 |

From the responses of students by preference to MIM in teaching chemical bonding as a method that improve their understanding of the concept, 26.7 % male students strongly agreed as against 31.7 % of female students, 21.7 % of males agreed as against 11.7 % of female students. But only 1.0 % of the male students and 6.7 % female students were not sure whereas none of the students disagreed or strongly disagreed. It was also observed from the result that 48.4% male students and 43.4 % female students supported that multimodal instruction method helps to improve their understanding of the concept. None of male or female students disagreed. The analyzed results also addressed the issue of whether MIM was going to motivate or not the gender groups of students differently. 96.8 % of the students comprising 48.9 % and 47.9 % of the male and females respectively confirmed that MIM motivated them to learn the concept. However 1.7 % and 0.3 % of the male and female respectively strongly disagreed. More females felt they were very comfortable and interested with using MIM for teaching than their male colleagues (female=50.0%, male=45.0%). Nevertheless, 95% of the students indicated the instructional method actually made them confortable and

interested learning the chemical bonding. From the analysis, it can be concluded that many male students felt MIM improved their abilities to interpret and comprehend the concept and could communicate well in science community as compared to the female students (female=41.7%, male=45.0%). The inability of students to interpret and comprehend the concept in the literature has being the problem of many science students in the classroom. Finally, more male students than female students stated they want the used multimodal instructional method to teach the concept. There was no male who disagreed or strongly disagreed with the usefulness of MIM as 3.3% and 1.7% of the female disagreed and strongly disagreed respectively with it.

## DISCUSSION

The study was sought to evaluate the impact of MIM on students' learning of chemical bonding, especially between female and male students. Students and mostly female students had always thought that the bonding concepts make chemistry difficult. Therefore they had no interest in the subject, which could have influence their inability to learn and understand the concepts. The findings from the pretest results in Table 1 confirmed the some reports that students generally difficulty in learning bonding concepts (Bernett, 2011; Coll&Treagust, 200). Most of the students (65%) scored lower range marks means that they did not understand the concepts. Only few students (65%) scored marks that was considered average performance but did not well understand the concept. A large number of the students who had difficulty of understanding the chemical bonding concept were female students (Table 2). This could have been among the reasons why female students did not want to be enrolled as science teacher trainees, which could have been the reason why few females are science teachers in schools. Based on this findings, MIM was developed and used to teach the concept, to see whether it would have impact on the improvement of students learning, different influences on female and male students understanding on chemical bonding and their interest of studying it. From the findings of the analysis between pretest and posttest results, it showed that there was a significant differences (p< 0.05, p=0.000, $\overline{X}\ difference = 10.107$) of students' pretest performance conducted before the use of MIM and posttest performance after the use of MIM.

The evaluated whether there were differential impacts of MIM and a significant mean difference between male and female students with respect to understanding chemical bonding concepts. When the students were instructed using MIM finding from the results in Table 4 indicated that there was no significant difference of the mean between male and female students (P-value = 0.233, p > 0.05). Both female and male students improved their performance in the posttest scores after they were instructed by MIN. This meant that, both groups of students understood the concepts and also no significant difference in performance of understanding levels. The finding of no significant difference after MIM was used to instruct concept was attributed to the fact that it catered for the learning differences of both male and female students in the classroom. This also had positive effect on the students' attitudes toward learning chemical bonding. The pretest result suggested a significant difference that indicated that male students had

relatively understood chemical bonding more than female students in terms of means scores, whiles female had higher post-test mean score, though no significant difference, showed the female relatively understood the concepts better (Table 3 and 4). It could be concluded that female were at the better side in the understanding of chemical bonding.

The analyzed results also addressed the issue of whether MIM was going to motivate or not the gender groups of students differently. 96.8% of the students confirmed that they motivated to learn the concept with the use of MIM. This outcome means that MIM in an effective strategy for all inclusive with regard to gender sensitive method of teaching scientific concepts. Motivation to learn a subject is one of the key factors for the effective learning which contributes to the choice of the subject area to teach or study in future. It is also observed from the analysis that more of the females felt they were very comfortable and interested with MIM of teaching than their male colleagues (female=50.0%, male=45.0%). This was confirmed in the females students scored marks in the above average performance range than male students. Nevertheless, 95% of the students indicated the instructional method actually made them felt comfortable and interested learning the chemical bonding. This supports the report that using different modes of instructions in an integrated form creates learning environments that cater for learning styles of students making then feel comfortable, interested and perform better in learning (Omrod, 2008). The findings suggested that MIM positively addressed the issue of female students having negative conception that chemistry is difficult and would not like to choose its area for study in future. The result also meant that when MIM is used to teach students, more females would have the confident and motivation to choose science as their major area of training as teachers. When they complete and become teachers in schools, they would become mentors for learning of science to their female students. They are luckily to also use MIM in their teachings which might have the same effect on their students. The findings showed that 85.7% of the students were very comfortable with the method to learn and understand the concept. Some of the reasons that were given by the student during the interview are that; their learning styles were catered for, it made them not easily forgot the concept, it increased the interest of learning chemical bonding concepts, it demystified the perception that the concept is difficult to learn and it helped to do away with misconceptions about the concept.

## CONCLUSION

The study evaluated the impact of MIM on students' learning of chemical bonding, especially between female and male students. The finding revealed that students, mostly female, had difficulty in understanding chemical bonding concepts. This made them not have interest in chemistry, and did not want to become Chemistry teachers. However, when both male and female students were instructed by MIM, their understanding of the chemical bonding was significantly improved without a significant difference between male and female students. The students were able to comprehend and interpret the concepts as expected by chemistry community. The method catered for learning difference of both male and female students. Most importantly, MIM had great impact on the development of female students' interest for chemistry and motivated them to

become science teachers who would be inspiration to their female students to study chemistry.

## Acknowledgements

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