

## GENDER DIFFERENTIATION IN CHEMICAL THERMODYNAMICS ACHIEVEMENT IN SELECTED SECONDARY SCHOOLS IN AKWA IBOM STATE

IBANGA, ANIEFIOK ADOLPHUS & A. A. O. MUMUNI

Curriculum Studies and Educational Technology, University of Port Harcourt, Choba, Port Harcourt

### ABSTRACT

The study investigated the gender differentiation in chemical thermodynamics using students with different cognitive styles adopting a pre-test, post-test control group design. The instruments for the study were the Cognitive Style Test (CST) for grouping the 320 students into three cognitive style groups and Achievement Test in Chemical Thermodynamics (ATCT) both having estimated reliability coefficients of 0.84 and 0.74 respectively, using the Pearson Product Moment Correlation formula (PPMC). Research questions and hypotheses which guided the study were appropriately stated. Data generated in the study were collated and analyzed using the descriptive and inferential statistic. Two-way Analysis of Covariance (ANCOVA) and student t-test were used for test of hypotheses. Results showed that there was no significant difference in students' academic achievement in chemical thermodynamics when taught with both the guided inquiry and conventional lecture methods, based on their cognitive styles. There was no significant difference in students performance given by their gender. The cognitive style interact with gender to affect students' academic achievement in chemical thermodynamics. Based on these findings, it was recommended that chemistry teachers should adopt guided inquiry method as a pedagogical intervention in teaching chemical thermodynamics in order to enhance improved students' academic achievement in the concept, irrespective of their gender.

**KEYWORDS:** Gender, Chemical Thermodynamics, Achievement, Guided Inquiry Method (GIM)

### INTRODUCTION

Gender differences in achievement in the sciences have been linked with variance in mathematical abilities, students attitude and preferences in learning, differential cognitive learning styles and individual differences. Many studies agreed that male students usually out perform their female counterparts in assessments particularly in the area of Mathematic and Science (Beller & Ganic, 2000). The science curricular review and introduction of innovation in subject matter instruction proposed by Okebukola (2002) and Ezelina (2004) is aimed at creating several common-ground science process goals in order for all science students irrespective of gender, to experience success, thus Uyoata, Inyion and Ekanem (2011) observed that there is no significant difference in performance scores between males and females in learning primary science in a cooperative small group instructional mode. Although, gender differentiation in achievement could be concept-biased or pedagogy-biased the necessity to evaluate gender differences in achievement in chemical thermodynamics adopting the guided inquiry method of teaching, is to measure the students' change in behavior.

More so, concepts of chemical thermodynamics at the secondary school curriculum include heat flow concept, chemical reactions and energy changes, entropy, enthalpy, chemical kinetics and principles of chemical equilibrium, among others. Ikeobi (2006) and Onwu & Ahiakwo (2000) identified these concepts as originally contained in the advanced level chemistry curriculum and has demand for mathematics knowledge and experimentation, if proper

conceptual understanding would be attained. The study measures gender differences in achievement in chemical thermodynamics among students taught using guided Inquiry method (GIM).

### **Statement of the Problem**

Gender differentiations have been identified in many studies. The thrust of innovative pedagogy is to reduce gender inequality in attainment of learning goals. Persistence in gender related differences may be due to learner's differential cognitive styles, attitude, inactivity and activity during the learning process which has created gender imbalance in professional causes such as Engineering, Mathematics, Medicine and others. The study therefore adopts the Guided Inquiry Method (GIM) in teaching the concepts of chemical thermodynamics in order to measure differences of achievement among male and female students.

### **Objectives of the Study**

The aim of this study was to investigate the gender differentiation in chemical thermodynamics among students with different cognitive styles, taught using the Guided Inquiry Method (GIM)

Specifically, the study sought to determine the extent to which:

- Students' academic achievement in chemical thermodynamics differs when taught with Guided Inquiry Method (GIM) based on their cognitive styles.
- Gender affect students' academic achievement in chemical thermodynamics when taught with Guided Inquiry Method (GIM).
- Gender affect students' academic achievement in chemical thermodynamics when taught with conventional lecture method (CLM).

### **Research Questions**

The study sought answers to the following research questions:

- Does students' academic achievement in chemical thermodynamics differ when taught with Guided Inquiry Method (GIM) based on their cognitive styles?
- Does gender affect students' academic achievement in chemical thermodynamics when taught with Guided Inquiry Method (GIM)?
- Does gender affect students' academic achievement in chemical thermodynamics when taught with conventional lecture method (CLM)?

### **Research Hypotheses**

The following null hypotheses (Ho) were tested in the study at 0.05 level of significance:

- There is no significant difference in students' academic achievement in chemical thermodynamics when taught with Guided Inquiry Method (GIM) based on their cognitive styles.
- Gender does not significantly affect students' academic achievement in chemical thermodynamics when taught with Guided Inquiry Method (GIM).

- Gender does not significantly affect students' academic achievement in chemical thermodynamics when taught with conventional lecture method (CLM).

### Significance of the Study

Based on the result of this study, academic achievement on the concepts of chemical thermodynamics can be attained if teacher's adopt guided inquiry method which is practical oriented. Students practice of some concepts allow for development of analytic skills which are in grained in most chemical thermodynamic concepts. The ministry of education would benefit from this study as they see the need to equip the chemistry laboratories for instruction in chemical thermodynamics.

### Research Design

The research design adopted for this study was a quasi-experimental design of non-randomized pre-test, post-test control group.

Two (2) groups (experimental and control) each consisting of three (3) cognitive style groups were used in the study. The three cognitive style groups for each of the experimental and control groups are:

Group I: Analytic Cognitive Style (ACS) group

Group II: Relational Cognitive Style (RCS) group

Group III: Inferential Cognitive Style (ICS) group

This design was chosen because the use of intact class is ensured throughout the research in order to control the reaction of experimentation and eliminate Multiple Treatment Interference (MTI).

Table 1 shows the non-randomized groups in the Pre-test, Post-test control group design.

**Table 1: Non-Randomized Groups Pre-Test Post-Test Design**

Variable	Pre-test	Treatment	Post-test
Experimental Group	X <sub>1</sub>	O <sub>1</sub>	X <sub>2</sub>
Control Group	X <sub>1</sub>	O <sub>2</sub>	X <sub>2</sub>

Where X<sub>1</sub>= Pre-test on experimental and control groups

O<sub>1</sub> = Treatment on experimental group using Guided Inquiry Method (GIM)

X<sub>2</sub> = Post-test on experimental and control group

O<sub>2</sub> = Treatment on control group using Conventional Lecture Method (CLM)

### Population of the Study

The population of this study was 600 senior secondary two (SS 2) chemistry students in the twelve (12) public secondary schools in Etim Ekpo Local Government Area of Akwa Ibom State (State Ministry of Education, LEC Etim Ekpo). These students, according to the provision of the National Curriculum for Chemistry, are required to learn the concepts of chemical thermodynamics.

### Sample and Sampling Technique

All the SS 2 Chemistry students from the eight (8) public senior secondary schools in the area of study were used in their intact classes totaling 320 students. The schools were selected based on their location and stratified proportionate sampling technique was used to select four (4) schools from each of the urban and rural locations. The selected schools were coeducational and offered chemistry with qualified chemistry teachers.

A random technique was used to designate two schools from each of the locations as 'experimental' and 'control' respectively. The Cognitive Style Test (CST) was administered on the sample (320 students) to identify and distribute them into three cognitive style groups of analytic, relational and inferential for each of the experimental and control groups. The schools sampled and the distribution of SS 2 chemistry students on the bases of their gender and cognitive style is as shown in table 2.0.

**Table 2.0**

<b>Experimental Group</b>					
<b>Urban schools</b>			<b>Rural schools</b>		
<b>Cognitive Style</b>	<b>Male</b>	<b>Female</b>	<b>Male</b>	<b>Female</b>	<b>Total</b>
Analytic	15	16	13	13	51
Relational	14	12	15	12	53
Inferential	13	13	14	13	53
<b>Total</b>	<b>42</b>	<b>41</b>	<b>41</b>	<b>38</b>	<b>163</b>
<b>Control Group</b>					
Analytic	14	12	14	14	54
Relational	13	13	14	13	53
Inferential	12	13	12	13	52
<b>Total</b>	<b>39</b>	<b>38</b>	<b>40</b>	<b>40</b>	<b>157</b>
<b>Grand total</b>	<b>81</b>	<b>79</b>	<b>82</b>	<b>78</b>	<b>320</b>

### Instrumentation

The research instruments for collecting data for this study were the Cognitive Style Test (CST) used for classification of students into different cognitive style groups and an Achievement Test in Chemical Thermodynamics (ATCT) used to determine the achievement of students in chemical thermodynamics.

The CST which was designed by the researcher and intended to identify the students' cognitive styles consisted of 10 multiple choice items while the ATCT, also researcher-designed, consisted of forty (40) multiple choice items and intended to determine students' academic achievement in the concept of chemical thermodynamics.

There were 3 options of choice for each item of the cognitive style test (CST). The options signified the three cognitive styles for this study viz:

Option A signified Analytic Cognitive Style,

Option B signified Rational Cognitive Style,

Option C signified Inferential Cognitive Style,

Students who took 60% and above of option A, B or C were grouped under analytic, relational or inferential cognitive styles respectively. The ATCT was used as pre-test and reshuffled (rearranged) and used as post-test on all study groups. There were four options of choice for each item of the ATCT. The items on the ATCT were based on the three

concepts of chemical thermodynamics for this study exothermic and endothermic reactions, enthalpy change ( $\Delta H$ ), and Entropy change ( $\Delta S$ ).

Students in the experimental group were taught the thermodynamics concepts using the Guided Inquiry Method lessons plan for 3 weeks. This instrument consisted of eleven (11) validated experiments/activities for the students to be involved in open-ended laboratory activities with the guide of the researcher, while students in the control group were also taught the same chemical thermodynamics concepts using the conventional lecture method lessons plan for a period of 3 weeks. This instrument consisted of the researcher's description of the experimental procedures and expected results, without involving the students in any laboratory activity.

### Validity of Instruments

The researcher designed Cognitive Style Test (CST) and Achievement Test in Chemical Thermodynamics (ATCT), used as instruments for this study, were validated by teachers and specialists in chemistry education in areas of content validity, test of relevance and ambiguity and vagueness of statements. Both the CST and the ATCT were re-assessed to identify the students' cognitive styles and determine their academic achievements in the concepts under study and were adjudged as adequate for the purpose of this study.

### Reliability of Instruments

The reliability of the CST and ATCT instruments for this study were conducted using test-retest method on thirty (30) students randomly selected from the research population who were not part of the sample for the study and analyzed using the Pearson Product Moment Correlation (PPMC) statistics).

The reliability coefficients were calculated as 0.84 for the CST and 0.74 for the ATCT respectively.

### Scoring of Instruments

In the Cognitive Style Test (CST) used in grouping the students into different Cognitive Style groups, an option to each item scored 10% (10 marks). The total score for the 10-item instrument was 100marks.

In the Achievement Test in Chemical Thermodynamics (ATCT) used as pre-test and post test on all the study groups, a correct answer to each question scored 2½ (2.5) marks. The scores were based on the correct option A – D chosen by the learners. The overall score for the 40 item multiple choice instrument was 100 marks.

### Data Collection Analysis

The instruments were administered by the researcher and two – research assistants. Data collected from students' performance test (pretest), before instruction and post-test (at the end of treatment) were used to answer the research questions and test of Hypothesis, using the stated relevant statistics.

## RESULTS AND DISCUSSIONS

### Research Question 1

Does the students' academic achievement in chemical thermodynamics differ when taught with guided inquiry method based on cognitive styles?

**Table 3: Analysis of the Students' Post-Test Scores from Experimental Group Based on Their Cognitive Styles**

Cognitive Style	N	Mean Score	SD
Analytic	57	51.00	7.44
Relational	53	49.31	7.73
Inferential	53	48.66	8.33

Results in table 3 revealed that the post-test mean scores of the students in ATCT taught with guided inquiry method were 51.00, 49.31 and 48.66 respectively for those that have analytic, relational and inferential cognitive styles with the corresponding standard deviation of 7.44, 7.73 and 8.33 respectively. Based on their mean scores it was observed that the analytic cognitive style group had the highest mean score followed by relational and then inferential cognitive style groups. It could then be deduced that students' academic achievement in chemical thermodynamics do differ based on their cognitive styles, when taught with guided inquiry method.

### Research question 2

Does gender affect the students' academic achievement in chemical thermodynamics when taught with guided inquiry method?

To answer this research question, mean and standard deviation of students' post-test scores from the experimental group based on gender was employed as shown in table 3

**Table 4: Analysis of the Students' Post-Test Scores from Experimental Group Based on Gender**

Gender	N	Mean score	SD
Male	84	50.69	7.95
Female	79	48.53	7.79

Considering the gender effect, table 4 revealed that the male students who were taught chemical thermodynamics using guided inquiry method had a mean score of 50.69, with a corresponding standard deviation of 7.95. The female students who were also taught chemical thermodynamics using guided inquiry method had a mean score of 48.53, with a corresponding standard deviation of 7.79. From here, it is observed that the male students outperformed their female counterparts by a mean score difference of 2.16. Based on this, it is deduced that gender do affect students' academic achievement in chemical thermodynamics when taught with guided inquiry method.

### Research Question 3

Does gender affect students' academic achievement in chemical thermodynamics when taught with conventional method (CLM)?

**Table 5: Analysis of the Students' Post-Test Scores From Control Group Based on Gender**

Gender	N	Mean score	SD
Male	79	51.33	8.66
Female	78	46.50	7.95

Table 5 revealed that the male students who were taught chemical thermodynamics through the conventional lecture method had a mean score of 51.33, with a corresponding standard deviation of 8.66. the female students who were also taught chemical thermodynamics though the conventional lecture method had a mean score of 46.50, with a corresponding standard deviation of 7.95. From this observation, the students performed better than their female parts by a mean score difference of 4.83. This shows that gender do affect students' academic achievement in chemical

thermodynamics when taught with conventional lecture method.

Further more, figure 1 shows the differences in gender performance in the concepts of thermodynamics after treatment of subjects based on their mean scored

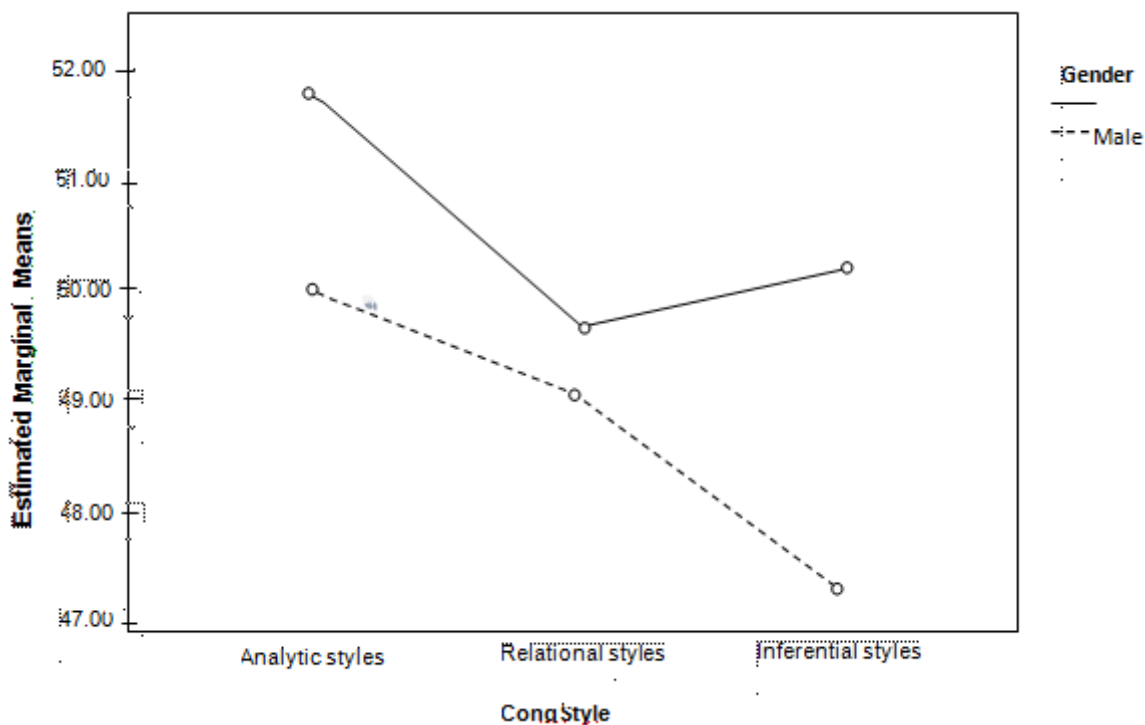


Figure 1: Estimated Marginal Means of Post Academic Achievement

**Test of Hypotheses**

**Hypothesis 1**

**Ho1:** There is no significant difference in students’ academic achievement in chemical thermodynamics, when taught with guided inquiry method based on their cognitive styles.

To test null hypothesis 1 (Ho1), two way analysis of covariate (2-way ANCOVA) of the students’ post-test scores from the experimental group was employed. The results obtained are as presented in table 6.

**Table 6: 2-way ANCOVA of Students’ Post-Test Scores on The Influence of Cognitive Styles on Academic Achievement in Chemical Thermodynamics among Students in Experimental Group Based on Gender**

Source of Variance	Sum of squares	Df	Mean square	F	Sign
Pre achievement	133.65	1	133.65	2.17	0.142
Group	213.36	2	106.68	1.73	0.179
Gender	189.75	1	189.75	3.08	0.081
Group X Gender	48.91	2	24.45	0.397	0.673
Error	14362.07	233	61.64		
Total	15050.40	239			

Table 6 revealed that the F-calculated value for cognitive style groups of 1.73 was significant at 0.179 level (P >

0.05) which is greater than 0.05, the chosen level of probability. Hence cognitive styles of students do not significantly influence their academic achievement in chemical thermodynamics when taught with guided inquiry method. The null hypothesis one is therefore upheld.

### **Hypothesis 2**

**Ho2:** Gender does not significantly affect students' academic achievement in chemical thermodynamics when taught with guided inquiry method.

Considering the gender effect on students' academic achievement in chemical thermodynamics, the calculated F-value of 3.08 in table 6 was significant at 0.081. ( $P > 0.05$ ), which is greater than 0.05 the chosen level of probability. Hence, gender does not significantly influence students' academic achievement in chemical thermodynamics when taught with guided inquiry method. Therefore, the null hypothesis 2 is retained.

### **Hypothesis 3**

**Ho3:** Gender does not significantly affect students' academic achievement in chemical thermodynamics when taught with conventional lecture method.

Considering the gender effect on students' academic achievement in chemical thermodynamics, the calculated F-value of 2.85 in table 7 was significant at 0.081 level ( $P > 0.05$ ), which is greater than 0.05 the chosen level of probability. Therefore, gender does not significantly influence students' academic achievement in chemical thermodynamics when taught with the conventional lecture method. Hence, the null hypothesis 4 ( $Ho_4$ ) is, therefore, retained.

## **DISCUSSIONS OF FINDINGS**

This study revealed no significant differences in students' academic achievement in chemical thermodynamics when taught with both the guided inquiry and the conventional lecture methods, based on their cognitive styles and gender, at 0.05 significant level.

This finding disagreed with the views of Babalola (2008) and Asuzu & Onwu, (2009) who posited that individuals approach scientific tasks in differing manner, hence the consideration of cognitive styles and gender are of less importance, based on instructions in chemistry and Klobb's (1998) experiential learning which predicted that students with different learning styles will respond differently to various teaching methods and that instructional strategies should match the learning styles of students. When Wu, Dale and Bethel (1998), adopted the use of concrete/abstract models and cognitive styles in teaching recursion, the result showed that students in the abstract learning style group performed better than those in the concrete learning style group in the learning of recursion. This showed some agreement with this finding despite the fact that conceptual models (abstract or concrete) were used which is similar to experimentation based on the use of guided inquiry method.

### **Summary of Findings**

The findings of this study are enumerated as:

- Students' academic achievement in chemical thermodynamics do differ based on their cognitive styles, even when taught with both the guided inquiry and conventional lecture methods.
- Gender do affect students' academic achievement in chemical thermodynamics even when taught with similar



teaching method.

- The guided inquiry method is more facilitative than the conventional lecture method in enhancing the academic achievement of students in chemical thermodynamics.
- There was no significant difference in students' academic achievement in chemical thermodynamics, when taught with both the guided inquiry and conventional lecture methods, based on their cognitive styles. Hence, null hypotheses 1 and 2 were upheld at 0.05 alpha.
- Gender did not significantly affect students' academic achievement in chemical thermodynamics when taught with both the guided inquiry and conventional lecture methods. Hence, null hypotheses 3 and 4 were upheld at 0.05 alpha level.

However, in comparison of the mean performance score, there was a significant difference in the facilitative effect of Guided Inquiry Method (GIM) and Conventional Lecture Method (CLM) as the guided inquiry method showed a higher level of enhancing academic achievement in chemical thermodynamics than the conventional lecture method.

## RECOMMENDATIONS

Based on the findings of this study, it is recommended that:

- Chemistry students should study co-operatively in order to improve their academic achievement in chemical thermodynamics
- Chemistry teachers should adopt guided-inquiry teaching method in order to eliminate intricacies in certain concepts and improve pedagogy of such concepts. This method arouses students' interest and active participation in the learning process.
- The state ministry of education and the state secondary schools' board should adequately supply concept-based science equipment to schools' laboratories to enable the learners and teachers have access to assorted science equipment and to utilize them in open-ended laboratory activity during the teaching and of chemistry in schools.

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