# Piagetian 5E Model and Students' Interest in Chemistry: Facing the Challenges of Global Competitiveness

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## Abstract

*The premise of the study was to examine the effect of Piagetian Intelligence 5E model on students" interest in Chemistry and its implication in enabling students face the challenges of global competitiveness in a world rapidly demanding individuals that possess 21st century competencies in the workforce. Two research questions and two null hypotheses guided the study. The study adopted a pre-test, post-test non-equivalent control group design. One hundred and forty-four Senior Secondary Class II students in Ihiala Local Government, Nnewi Education Zone, Anambra State Nigeria, participated in the study. The reliability of the instrument Mole Concept Interest Scale (MCIS) was 0.75. Mean and standard deviation were used to answer the research questions while analysis of covariance (ANCOVA) was used to test the hypotheses. Results of the study showed that 5E Piagetian Model did not only promote students" interest in the mole concept aspect of Chemistry but also encouraged the acquisition of generic and soft skills more than the traditional teaching methods. Gender was found to significantly affect students" interest in quantitative Chemistry. Recommendations arising from the study urged Chemistry teachers to recognize the responsibility of learners as the active agents of knowledge construction who own the prerogative to connect new knowledge to prior knowledge in their mental strictures, to think critically and to participate actively in the learning process. The teachers" roles as facilitators are meant to enable students effectively apply new knowledge that could help them build their capacity to face the challenges of life after school.*

**Key Words**: Piaget, 5E Learning Cycle, Interest, Skills, Chemistry

## Introduction

At the heart of Piaget‘s developmental model (Piaget, 1977), is the education of the child in a manner that supports his/her interests and needs. The cognitive development of the child holds prominence for the Piagetian constructivists. Cognitive learning theory focuses on the mental constructs and organizational patterns that an individual develops in the process of formation of reasoning patterns in response to his/her inadequacy in using new present reasoning patterns to cope with a demand (Karplus, 1977). In the course of formation of new reasoning patterns, the individual actively engages his/her internal mental process to combine new experiences and to generate logical operations. Research has confirmed that knowledge is stored as a network of concepts in the brain of the learner and that learners construct knowledge by making connections between new information and their existing conceptual network or mental structures (Woolfolk & Margetts, 2013; Peterson, Fennema & Carpenter, 1988).

The process of knowledge construction comes about through the dialectical interplay of assimilation and accommodation. Assimilation is ―an active process of making meaning out of experience‖ (Fosnot, 1989, p 3) while accommodation is the changing of one‘s thinking in order to strive to equilibrium (Piaget, 1976). Prior to accommodation the individual‘s mind is a state of equilibrium (Atherton, 2009) but with the assimilation of new data, the mental process must go through a process of change which may result to change in organizational structure. In other words, to gain equilibrium learners must reorganize and change their initial concepts which often require challenging their current inadequate conceptions or views which they brought to the classroom. Equilibrium occurs when the leaner is able to organize the new concepts with other concepts and has gained conceptual understanding manifested in the knack to view knowledge objectively and to deal with problems.

The 5E model was informed from the principles or work of Jean Piaget (Piaget & Inhelder, 1969; Piaget, 1976). The underpinning structure of the 5E model stemmed from the principle that learners come to classroom with their own ideas which the facilitator may need to modify in addition to arousing learners‘ interest and motivation by eliciting their prior knowledge (Trowbridge & Bybee, 1990). The 5E is a learning cycle which was first used as an inquiry lesson model in the Science Curriculum Improvement Study programme, a K-6 science programme in the early 1970s. Karplus (1967) and his colleagues designed the first model which comprised 3 stages (exploration, invention and discovery). The 3 phase model later developed into 5E in Biological Science Curriculum Studies (BSCS) science programmes. The 5E model is structured in such a way that learners are given opportunity to work out explanations for themselves through a variety of learning experiences and thought provoking questions posed by the facilitator. The stages of the cycle are: engagement, exploration, explanation, extension/elaboration and evaluation. Each phase arouses the motivation, interest, reflective and active participation of learners. Figure 1 shows the stages of the 5E and what happens at each stage.

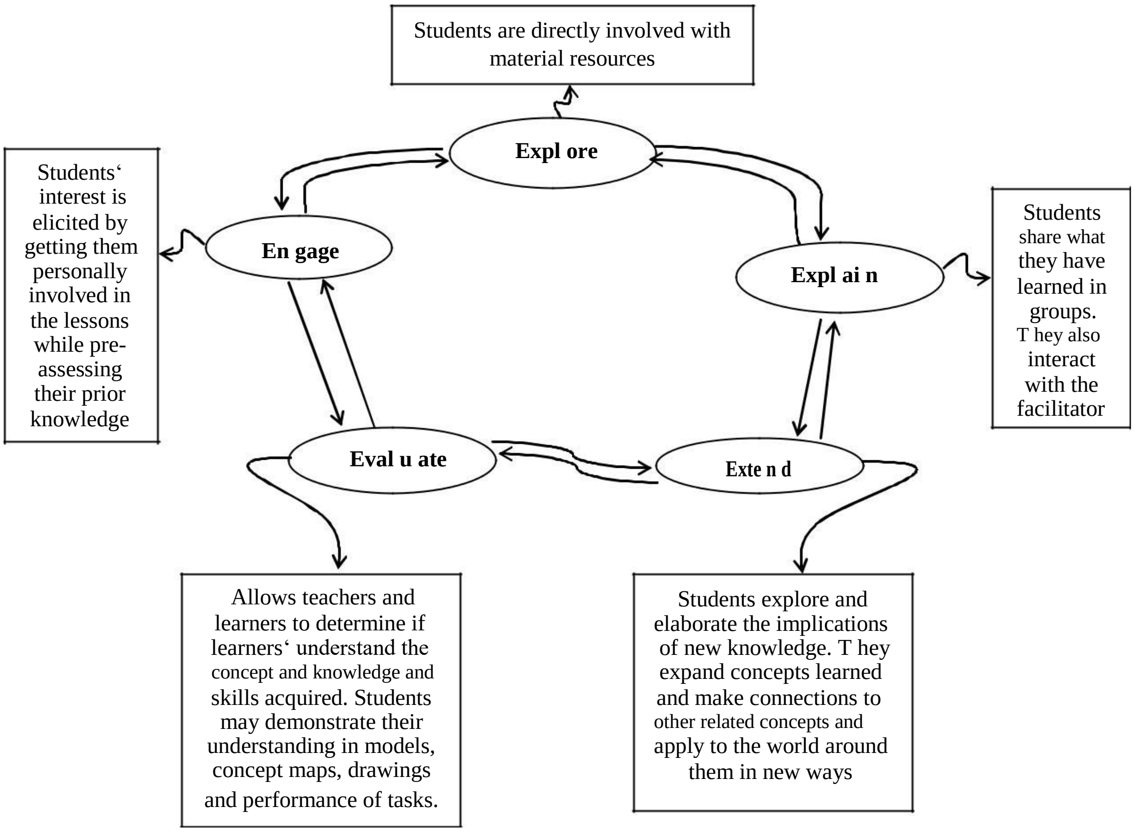


**Figure 1. 5E Learning Cycle**

Thus, the interest of the learner and conceptual understanding which the leaner gains through active participation, creative and critical thinking are important to the constructivist.

On the contrary, traditional instruction is heavily driven by ―teacher-talk‖ with the teacher as the central focus who is seen as the knowledge transmitter to passive students (empty vessels) into whom knowledge is to be poured. The leaner's role is to follow the teacher's instruction and later regurgitate the concepts he/she was taught (Adesoji & Oginni 2012; Akar, 2005). The figure below summarizes the characteristics of the traditional approaches.

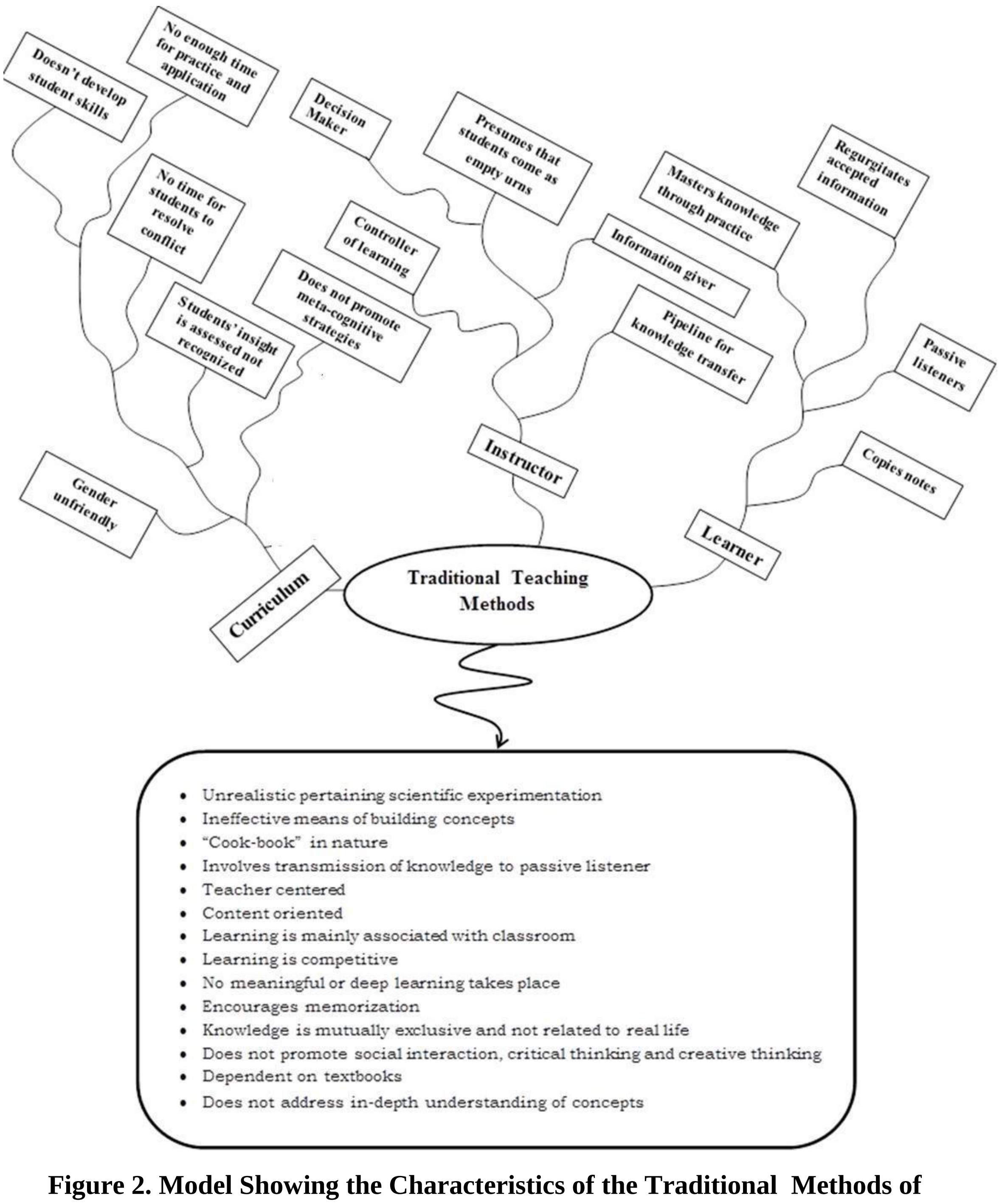


**Figure 2. Model Showing the Characteristics of the Traditional Methods of Teaching**

Several studies have attributed students' lack of interest and motivation in Chemistry to teachers' persistent use of traditional methods (Bamindele & Oloyede, 2013; Woldeamanuel, Atagana & Engida, 2013; Taurina, 2007). Recent studies (Bamindele & Oloyede, 2013; Opara & Waswa, 2013) confirm that chemistry teachers preponderantly use the traditional approaches which make Chemistry uninteresting to students and eventually lead to failure. Yet, a motivating interest can result to successful achievement in a particular situation (Crow & Crow, 1956) and trigger the curiosity of learners to want to know more and expand their existing knowledge (Ainley, 2012) to related concepts in chemistry and real life. Research has shown that when students develop a positive attitude towards teaching styles their learning performance also improves (Clarke & Nelson, 2012; Hokkanen, 2011; Young, Klemz, & Murphy, 2003). According to Abrantes, Seabra and Lages (2007), learner focused and interactive teaching methods are more appreciated by students.

Abrantes *et al*. therefore, encouraged instructors to use instructional methods that (i) attract students' active participation; (ii) that are friendly to students and catch their attention; (iii) that are well structured and organized, as such methods not only enhance students' interest but also have significant impact on learners perception of learning. This accords with Piaget's principle on learning, in the sense that Piaget underscores the awareness that if children are exposed to exploring environment they will be interested to learn. Thus, the accommodation that occurs when learners attain equilibrium with the challenges of new experiences is satisfying (Piaget, 1964). The 5E cycle exposes learners to a variety of activities which challenge their potentials to think creatively and actively participate in the learning process with a motivational interest.

Research has shown that there is a strong relationship between learners' performance, effect of teaching method and students' enjoyment of learning processes (Clarke & Nelson, 2012). However, the persistent use of the traditional approaches by Nigerian chemistry teachers appears to concur with Nwosu (2004) who opined that most science teachers do not possess prerequisite knowledge needed for activity based learning. The net effect is the observed failure annually recorded in chemistry at the West African Secondary School Certificate Examinations (WASSCE) because learners are not sufficiently motivated. Several studies have encouraged the use of the 5E model in the classroom because it is based upon effective and proven education theories (Bybee, Taylor, Gardner, Scotter, Powell, Westbrook & Landes, 2009). The study therefore was an elaboration of the usability of the 5E model that compares its effect with the traditional methods vis-a-vis students‘ interest on the mole concept in Chemistry.

The study was guided by the following research questions:

(i) What is the effect of 5E Piagetian model on the mean interest scores of students on the mole concept in chemistry?

(ii) What is the effect of gender on the mean interest scores of students in selected chemistry topic?

It was hypothesised that:

$Ho_1$ There is no significanteffect of the 5E Piagetian model on students‘ interest in chemistry.

$Ho_2$ There is no significant effect of gender on students‘ interest in selected chemistry topic

## Materials and Methods

The study design was a pre-test post-test quasi-experimental non-equivalent control group design. The study sample was made up 144 form III Chemistry secondary school students purposively selected from all the four single-sexed schools in the study area: that is, two male-only and two female-only schools in Ihiala Local Government Area. Non-equivalent control group design was used because eight intact classes were involved in the study (two classes per school – 2 classes from 2 boys‘ schools and 2 girls‘ schools respectively). However, eight intact classes included only the students offering chemistry in Form III at the time of the study. Simple random sampling was used to assign the intact classes in the same school to treatment and control groups. The treatment group which was exposed to the 5E model constituted 74 subjects (36 girls & 38 boys) while the control group was also made of 77 (36 girls & 41 boys). To obtain equal replication of subjects the responses of 36 boys each from the control and experimental groups were selected using simple randomization. Therefore, the total sample used for the study was 144: 72boys and 72girls.

## Instrument for Data Collection

The instrument, Mole Concept Interest Scale (MCIS), was a 26-item Likert-type response scale format of Strongly Agree (SA); Agree (A); Disagree (D); Strongly Disagree (SD). The students were required to complete the questionnaire which was intended to be an extension of their test of understanding of the chemistry concepts and application to real life vis-a-vis the extent the method used had captured their interest. The items were summed up to produce a total score concentrated on students' sense of enjoyment, applicability of learned skills to real life, acquisition of process skills and social interaction.

## Trial Testing and Reliability

The instrument was trial tested on 30 form III chemistry students in a school in Oyi Local Government Area after validation. The internal consistency of the instrument was established using Cronbach alpha reliability method and a score of 0.75 was found.

## Instructional Procedure

The control group was taught using the traditional methods of lecture, discussion and teacher demonstration. Students listened to the teacher, copied notes, answered teacher's questions and did assignments following the procedure outlined by the teacher. Opportunity was not provided for students to interact in groups and negotiate the meaning of the concept under study. The experimental group was taught using the 5E model. Summary of a lesson is given in Figure 3 to demonstrate the activities at each stage.

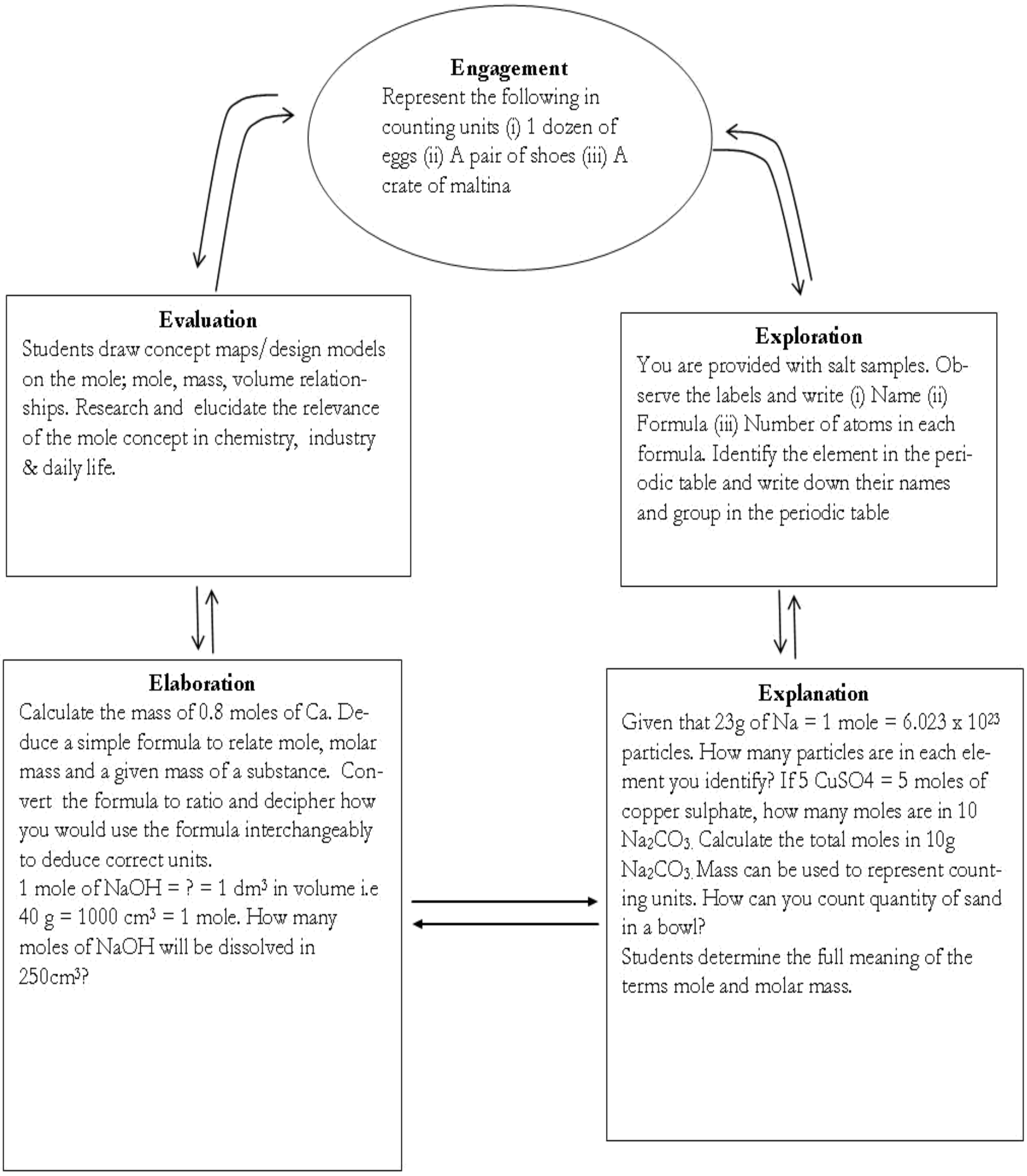


**Figure 3. 5E Model: Instructional Procedure on the Mole Concept**

## Results and Discussion

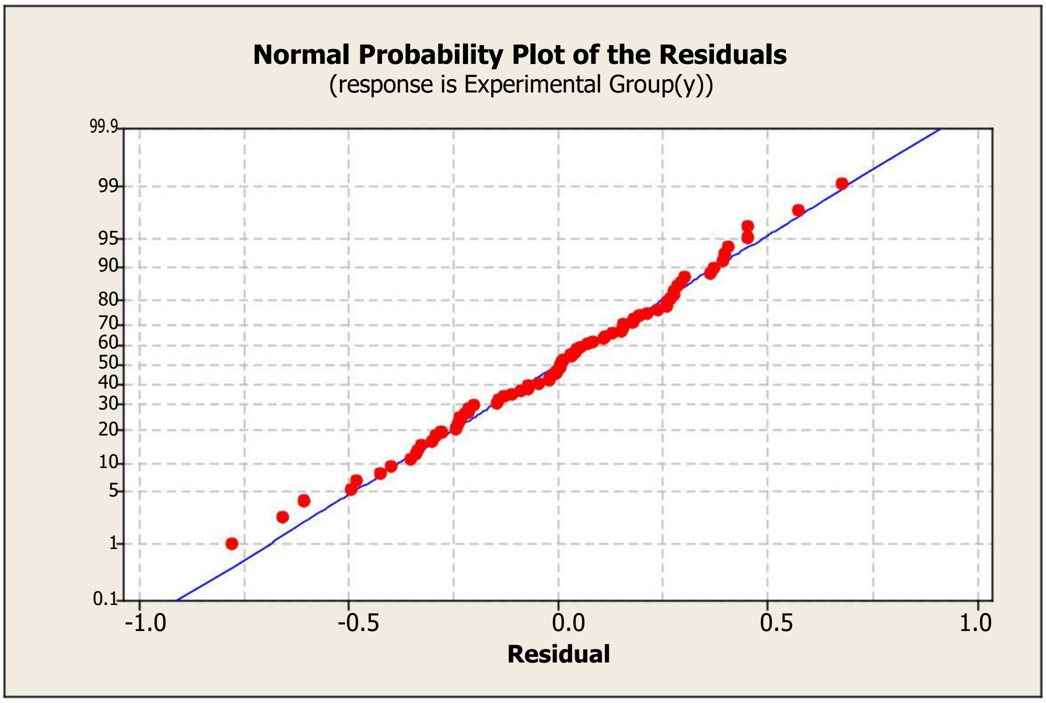


**Figure 4. Test of Assumption for Linearity between the Dependent Measures and the Independent Variables Regression Analysis: Experimental Group (y) versus Experimental Group (x)**

As shown in Figure 4 above, the data follows a normal distribution

**Table 1. Regression Analysis: Experimental Group (y) versus (x)**

| Predictor | Coef | SE Coef | T | P |
|---|---|---|---|---|
| Constant | 1.7806 | 0.3142 | 5.67 | 0.000 |
| Experimental Group(y) | 0.5999 | 0.1114 | 5.38 | 0.000 |

S = 0.296406 R-Sq = 28.7% R-Sq(adj) = 27.7%

**Table 2. Analysis of Variance Experimental Group (y) versus (x)**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| Regression | 1 | 2.5470 | 2.5470 | 28.99 | 0.000 |
| Residual Error | 72 | 6.3257 | 0.0879 | | |
| Total | 73 | 8.8727 | | | |

The p-value in the Analysis of Variance table (0.000), indicates that the relationship between (y) and group (x) is statistically significant at the level of .05.

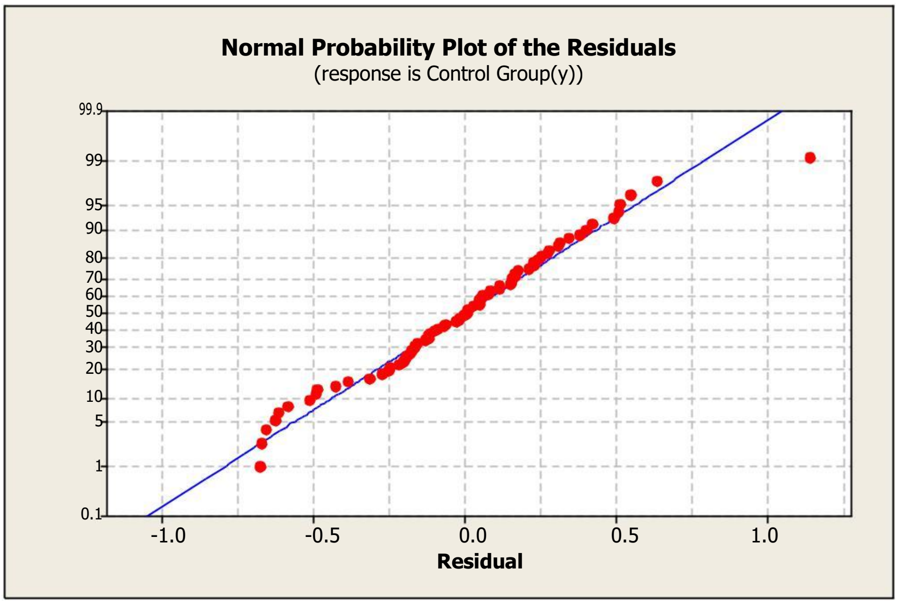


**Figure 5. Regression Analysis: (y) versus (x)**

The graph shows that the data follows a normal distribution.

**Control Group**

The regression equation is

(y) = 1.23 + 0.800 (x)

**Table 3. Regression Analysis Control Group y versus x**

| Predictor | Coef | SE Coef | T | P |
|---|---|---|---|---|
| Constant | 1.2328 | 0.3574 | 3.45 | 0.001 |
| Control Group(x) | 0.8000 | 0.1261 | 6.34 | 0.000 |

S = 0.341805 R-Sq = 35.9% R-Sq(adj) = 35.0%

**Table 4. Analysis of Variance Control Group y versus x**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| Regression | 1 | 4.7014 | 4.7014 | 40.24 | 0.000 |
| Residual Error | 72 | 8.4118 | 0.1168 | | |
| Total | 73 | 13.1132 | | | |

The p-value in the Analysis of Variance table (0.000) indicates that the relationship between (y) and (x) is statistically significant at the level of .05. This is also shown by the p-value for the estimated coefficient of control group (x), which is 0.000.

To determine the effect of 5E Piagetian Model on the mean interest scores of students in mole aspect of chemistry, results of the male and female students for the experimental and control groups are shown in Table 5.

**Table 5. Means and Standard Deviations of Students' Scores in Post-Treatment (MCIS) (By Treatment by Gender)**

| | | Gender | | |
|---|---|---|---|---|
| | | **M** | **F** | **Overall** |
| Experimental Group | Mean Scores | 3.35 | 3.45 | 3.40 |
| | SD | 0.28 | 0.31 | 0.30 |
| | N | 36 | 36 | 72 |
| Control | | 2.49 | 3.35 | 2.92 |
| | SD | 0.29 | 0.33 | 0.31 |
| | N | 36 | 36 | 72 |
| Overall | | 2.42 | 3.40 | 2.91 |
| | SD | 0.30 | 0.32 | 0.30 |
| | N | 72 | 72 | 144 |

The table shows that the overall mean interest score of students taught through the 5E model (experimental group) is 3.40 while the control group taught by the traditional method had an overall mean score of 2.92. Therefore, the experimental group apparently scored higher than the control group. The level of significant difference was examined in hypothesis one.

**$Ho_1$** There is no significant effect of 5E model on students' interest in the mole aspect of chemistry.

**Table 6. Analysis of Variance (ANCOVA) of Students' Interest Scores (Gender by Teaching Method)**

| Source of Variation | Sum of Squares | Degree of freedom | Mean square | Significance of F | Decision |
|---|---|---|---|---|---|
| Covariate | 16.88 | 1 | 16.88 | 0.00 | S |
| Main Effects (pretreatment) | 43.97 | 3 | 14.54 | 0.00 | |
| Teaching Method | 2.52 | 1 | 2.52 | 0.00 | S |
| Gender | 1.75 | 1 | 1.75 | 0.00 | S |
| Teaching Method (x Gender) | 4.55 | 1 | 4.55 | 0.00 | S |
| Explained | 47.99 | 4 | 12. 15 | 0.00 | |
| Residual | 22.55 | 175 | .080 | | |
| Total | 36 | 141 | .20 | | |

Table 6 shows that teaching method as main effect was significant on the interest of students in mole aspect of chemistry (F = 0.00). The null hypothesis of no significant difference between the experimental and control group is therefore rejected.

To examine the effect of gender on the mean interest scores of students, Table 5 revealed an overall mean score of 3.40 for the female and 2.42 for the male students. By implication gender seemed to affect students‘ interest in the mole aspect of chemistry. However, the extent of variance in the scores was further determined using analysis of covariance using the second hypothesis stated below.

**$Ho_2$** There is no significant effect of gender on students‘ interest in the mole concept of chemistry.

Table 6 shows that gender is significant on students‘ interest in the mole aspect of chemistry, F= 0.00. In other words, the null hypothesis of no significant difference between the mean interest scores of students is rejected. The observed difference between the overall mean interest score of female students (3.40) and (2.42) for the male students is thus established to be correct.

The findings of this study showed that the 5E Piagetian model significantly enhanced students‘ interest in the mole aspect of chemistry. This seemed to agree with Young, Klemz and Murphy (2003) who opine that when students develop a positive attitude toward teaching styles their performance not only increases but also their interest. The strong relationship between teaching method and students‘ enjoyment of learning processes as asserted by Abrantes, Seabra and Lages (2007) were found to be apparent in this paper. Thus, learner-centred, interactive teaching methods are more satisfying to learners than teacher-centred methods. Finally, this paper has given further credence to the fact that the 5E model fosters learners‘ critical thinking and creativity evinced during their active participation and interaction in groups. Therefore, the skills developed and encouraged by the Piagetian Model are enabling for students to face the challenges of global competitiveness which they are bound to experience in the market economy after school.

## Conclusion

The premise of this study was to provide an evidence-base for the Piagetian 5E model as an elaboration of earlier researches done on the model due to its underpinning on sound theory. Earlier studies such as Ergin, Kanli and Unsal (2008) recommended the continued empirical research on the method to ascertain its applicability and usability in helping students enjoy science, understand and apply scientific process and concepts in different cultural and classroom situations. Thus, by the study science teachers in developing countries especially Nigeria are urged to keep in mind the fundamental purpose of education while making choice of teaching methods. In a rapidly growing and dynamic world with a broad knowledge and innovative base, it is essential that students gain the right skills and competencies that will equip them to compete in the demand driven economy. Teaching methods which do not prepare students to think, reason and to respond effectively and efficiently to the rapid changes in the globalized world should be discouraged. Hence, since studies have shown that the traditional approaches do not respond to learners‘ needs and interests, teachers are by this study urged to innovatively apply the 5E model and methods that challenge students‘ creativity and critical thinking in the teaching of science. This will prepare them to face the challenges they must meet after school.

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