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# EFFECT OF INTERACTIVE-ENGAGEMENT, ANALOGY-ENHANCED STRATEGIES AND LOCATION ON STUDENTS' ACADEMIC PERFORMANCE AND SELF-EFFICACY IN CHEMISTRY

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# Effect of Interactive-Engagement, Analogy-Enhanced Strategies And Location on Students' Academic Performance and Self-Efficacy in Chemistry

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## Abstract

The focus of this study is to investigate the location effect of interactive-engagement and analogy-enhanced learning strategies on the academic performance and self-efficacy of students in chemistry. The population of the study consisted of all the Senior Secondary School Two (SSS II) students offering Chemistry in all the 187 public senior secondary schools in Ekiti State, Nigeria. 198 SSS II students offering chemistry from the intact classes of six selected secondary schools were the sample used for the study. The selection of the sample for the study was done through multistage sampling procedure. Quasi experimental design of the pretest, posttest control group design was adopted for the study. The students were divided into three groups (two experimental and one control); one of the experimental groups was exposed to interactive-engagement strategy and the second group was exposed to analogy-enhanced strategy while the control group was taught with conventional learning strategy. Two research instruments; Chemistry Students' Performance Test (CSPT) and Students' Self-Efficacy Rating Scale (SSERS) were used for collection of data. Analysis of Covariance (ANCOVA) was the inferential statistics used to analyse the data gathered. Findings of the study showed no significant location effect of interactive-engagement and analogy-enhanced strategies on the students' performance and self-efficacy in Chemistry (($F_{2,191}$= 0.207; $p>0.05$ and $F_{2,191}$= 312.238; $p<0.05$). Students' school location and treatment had no significant interaction effect on their performance and self-efficacy in Chemistry. It was recommended that Chemistry teachers should adopt interactive-engagement and analogy-enhanced learning strategies to improve students' performance and self-efficacy.

**Introduction**

The dichotomy existing between rural and urban centres in terms of availability of social amenities such as electricity, pipe-borne water, infrastructures among others has favoured urban areas than the rural areas. Rural areas appears to be disadvantaged in terms of social amenities; this has short changed this areas from attracting large population but otherwise give room for exodus to the urban centres. Experience teachers would prefer to work in schools located in the urban centres due to life conveniences available in these areas.

Given the increasing demands of rural areas and the influence of school location, learning strategies are critical for educating a wide range of students wherever they may be. Teachers must educate students interactively and provide students with a proper analogy that can clarify the principle learned in the classroom to increase student performance and self-efficacy in subjects taught in schools.

Interactive engagement is made possible by asking or challenging learners to reflect and do something that demands reflection. Students communicate with one another, with the teacher as mentors or guides , or even as instructor driven materials (on paper or computer). The interactive-engagement learning strategy promotes conceptual comprehension with the aid of intellectual and often hands-on activities that deliver immediate feedback through interaction among peers and instructor(s). Interactive engagement is a form of instruction that incorporates concept testing, class-wide discussion, and instant student-response-system, which has been established to improve secondary school classes (Meltzer and Manniwan, 2007). The teachers give the concept questions to stimulate minds-on-activities that would engage the students in class-wide discussions. Usually, the concept questions used in interactive-engagement are multiple-choice questions. The questions are given ahead of the actual classes and are introduced at the commencement of the class. These will eschew class-wide discussion on the concept, fostering collaboration and emphasizing conceptual understanding (Lorenzo, Crouch & Manzur, 2006).

The use of a student-response-system and a short presentation by the teacher during interactive engagement strategy enables the teacher to shed light on any misconception by the students; while the response system gives instant feedback to the students and at the same time inform the teacher of goal progress. The anticipation of desirable outcomes motivates students to persist and work harder towards better performance (Cook, 2010).

The study of Cahyadi (2007) showed that an interactive method of teaching has many beneficial effects on motivation and learning of students. He further observed that an instructional model where students participate in the process of investigation and discoveries by interacting with one another and with the teaching and learning materials has been shown to improve students' fundamental understanding of Chemistry. Moreover, Ezrailson, Karmon, Loving & Mcintyre, (2006, in its Spanish initiations) suggested that an interactive engagement learning approach model includes a pre-class work on the concept to be learned, which is inverse of the usual practice of giving post-class work as assignment/homework. This teaching strategy also involves concept testing and an instant student response system (which in this study will be a flashcard response system). The pilot study conducted by Cook (2010) on the use of interactive-engagement instructional strategy as a vehicle for promoting students' performance indicated that students exposed to interactive-engagement obtained grade-potential improvement that was 2.8 times greater than those exposed to the conventional instructional strategy. Hake (2002) submitted that this approach enhances self-efficacy and stimulates minds-on-activities.

An analogy is a way to describe the relative relationship between two terms, which are compared to each other as they are related to each other. This learning approach employs concepts familiar to the students to include an analog bridge to an unfamiliar definition that motivates and stimulates students' interest (Orgil & Thomas, 2007). According to Duniya (2009) an analogy is a comparison of something unfamiliar with something familiar to explain a shared principle; for example, when a teacher wants a student to learn from what they already know. An analogy is built on the learners' existing knowledge framework, so they are not starting from scratch. Analogy-enhanced instructional strategy helps students form initial mental models of key science concepts by facilitating the introduction of concepts in concrete, meaningful, and relevant ways (Samara, 2013). Sanni (2006) opined that analogy is one of the constructivist frame's teaching strategies that has proved effective in preventing and overcoming poor performance and wrong perception of the students. Sanni (2006) reported three benefits of analogies as an instructional strategy for abstract concepts. These are (i) it provides visualization of abstract concepts (ii) it helps compares similarities of the students' real world with the new concept; and (iii) it has motivational functions.

The following are other benefits that can be derived from analogy instructional strategy:

1. The use of analogy instructional strategy reduces anxiety level and phobia which are some of the causes of low performance in Chemistry (Mayo, 2006).
2. Analogy instructional strategy provides a bridge between prior knowledge and the new information, hence facilitate students comprehensibility and learning. These also help by providing visualization of abstracts concepts (Aybuke & Omen, 2012).
3. Analogy instructional strategy helps in stimulating and sustaining the interest of the learner throughout the instructional period because children generally enjoy storytelling (Sanni, 2006).

Kilic & Umdu-Topsakal (2011) indicated that the use of analogy technique has a positive effect on learning. Kayhan (2009), Aykutlu and Sen (2012) in their separate studies, conducted on the usage of analogies as a means of instruction. It was concluded that the use of analogical models positively affected the performance of the students. Bramwell and Rainford (2014) also reported a significant increase in performance of students exposed to analogy-based pedagogy compared to those taught with the conventional strategy.

Adebule & Aborisade(2013) have submitted in a study on the effect the school has on secondary school students' attitude to maths, that students resident in urban centers, especially where higher institutions such as the Polytechnics and the Universities are situated, could perform better and be more inclined toward higher education than those in rural areas.

Owoeye and Yara(2001) have argued in their study on the location and the academic performance of secondary schools, that the variety of academic performance literature reports on location are not definitive, although others claim that urban students perform better than their rural counterparts while some of them have submitted that there were no improvement in results over others (urban or rural) because their performance is the same. Also, Kolawole and Popoola (2011) found no significant difference in the performance mean score of student's from rural and urban areas in mathematics, as they examined four Ability Process Dimensions (4APD) as an alternative to strengthen the teaching and learning of basic mathematics.

Interactive-engagement and analogy-enhanced instructional strategies for the teaching of physical chemistry and other environmental sciences have been shown to increase students' performance and knowledge substantially. There has been little work on the use of Interactive-engagement and analogy in organic chemistry, including its effects on self-efficacy of the students. It is fair to conclude that if rural vulnerabilities come to an existence, major learning deficits in chemistry are likely to arise. Further study is required in view of these inconclusive conclusions to affirm or overturn the otherwise protracted question on the impact of school location (Rural/Urban

dichotomy) on the academic performance of secondary school chemistry students with regard to the two recent innovative interactive-engagement and analogy-enhanced teaching strategies.

**Objectives**

This study focuses on the location effect of interactive-engagement on the performance and self-efficacy of students in chemistry. Specifically, the study investigates:

1. effect of school location, interactive-engagement and analogy-enhanced strategies on secondary school students' performance in chemistry.
2. effect of school location, interactive-engagement and analogy-enhanced strategies on secondary school students' self-efficacy in chemistry.

**Hypotheses**

Ho1: There is no significant effect of school location, interactive-engagement and analogy-enhanced strategies on the students' performance in Chemistry.
Ho2: There is no significant effect of school location, interactive-engagement and analogy-enhanced strategies on secondary school students' self-efficacy in Chemistry.

**Methods**

The research design that was used in this study is quasi-experimental design that employed pre-test, post-test and control group design. The design is as shown below:

Experimental group 1 (E1) $O_1\ X_1\ O_2$
Experimental group 2 (E2) $O_3\ X_2\ O_4$
Control group (C) $O_5\ X_C\ O_6$

Where:

$O_1, O_3, O_5$ = Observation (Pre-test)
$O_2, O_4, O_6$ = Observation (Post-test)
$X_1$ = Treatment (Interactive-engagement strategy)
$X_2$ = Treatment (Analogy-enhanced strategy)
$X_C$ = Treatment (Conventional strategy)

The targeted population of this study consisted of all the 5,046 senior secondary school (SSS) II students offering Chemistry in all the 187 public senior secondary schools in Ekiti State, Nigeria as at the time of the study.

The study's sample entailed all the 198 SSS II students offering Chemistry in intact classes of the six secondary schools selected for the study. The selection was done through multistage sampling procedure. Stage one involved random selection of three Local Government Areas from Ekiti State. Stage two involved the selection of two schools from each of the selected Local Government Area using simple random sampling technique (experimental and control group) and stratified random sampling (rural and urban) technique. All together six schools (three rural and three urban) were randomly selected.

The two instruments used for the study were Chemistry Students' Performance Test (CSPT) and Students' Self-Efficacy Rating Scale (SSERS). Three Instructional Guides for Teachers based on the Instructional Strategies; Guide for Interactive–Engagement Strategy (GIES), Guide for Analogy-Enhanced Strategy (GAES) and Guide for Conventional Instructional Strategy (GCIS)

***Chemistry Students' Performance Test (CSPT)***: The CSPT was drawn by selecting questions relating to the topics from Organic Chemistry covered by this study. These are; alkane, alkene, alkyne and aromatic hydrocarbon). The CSPT comprises two sections. The first section was designed to obtain demographic data such as; name of school, class, sex, age and location. The second section of the CSPT was a 30 – item multiple choice questions. All the items in CSPT were drawn in line with Bloom's taxonomy of cognitive domain and educational objectives. From the table of specification, equal number of items survived scrutiny to evaluate knowledge, comprehension, application, analysis, synthesis and evaluation.

***Student Self-Efficacy Rating Scale (SSERS)***: This instrument was adapted from High School Chemistry Self-Efficacy Scale (HSCSS) by Chiu (2013). The items on the High School Chemistry Self-Efficacy Scale were reframed to suit the present study. It is made up of two sections; A and B. Section A was concerned with demographic information on gender and location. Section B consisted of a Likert type scale with 20 items that the students responded to by ticking the option most agreeable to them from the arrays of options; such as Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD). The response scale was scored as follows:

Strongly Agree (SA) = 4 points, Agree (A) = 3 points, Disagree (D) = 2 points and Strongly Disagree (SD) = 1 point for positive items and the reverse for negative items i.e. Strongly Agree (SA) =1 point, Agree (A) =2 points, Disagree (D) = 3 points and Strongly Disagree (SD) = 4points.

***Instructional Guides****:*

Instructional Guide for Teachers (IGT) on the three instructional strategies: These are stimulus instruments teaching guides prepared by the researcher for the teachers on interactive-engagement and conventional instructional strategies respectively. They were used during the briefing periods for teachers in the experimental and control groups. The stimulus instruments consisted of the step-by-step procedure for teaching organic chemistry with the strategies.

***Guide for Interactive-Engagement Strategy (GIES)***: This was divided into stages as reflected on the model of interactive-engagement pedagogy adopted from Manzur, (1997).

Stage 1: Introduction of the topic and pre-reading of the text assignment.
Stage 2: Concept-questions will be posed to students on the pre-read text assignment.
Stage 3: Students will vote their answers using flash cards.
Stage 4: Students will engage in class-wide discussion.
Stage 5: Students will re-vote their answers using flash cards
Stage 6: The teacher will lead the students in correction of misconceptions and give detailed explanation where needed.

*Flash cards as student response system:* Flash cards were used as the student response system in this study. This is because most of the secondary schools are not yet equipped with the electronic presentation software system, hence in a bid to be as practical as possible, flash cards were used. The flash cards were assigned colours as follows:

Green – option A
Black – option B
Red – option C

***Guide for Analogy-Enhanced Strategy (GAES):*** This guide was developed using the three-stage model of construction of analogy given by Amaechi (1995). This model employed the following paradigm;

- Generating the original analogy for course principle.
- Evaluating this analogy with constructive feedback from students and co-instructors.
- Modifying the initial analogy in light of others' appraisal.

Nevertheless, it should be noted that analogies could be generated on the spur of the moment. Analogy used in this study will be formally documented to create uniformity and enhancement. The steps involved in this model of instructional analogy as developed by Radford (1989) and modified by Treagust, Harrison and Venville (1998) are:

Stage 1: The teacher will select the vehicle of transfer.
Stage 2: The teacher will position the analogy and integrate it throughout the concept to be taught.
Stage 3: The student will present the anecdotal analogy.
Stage 4: The student will compare the analogue to the target on point by point matching (Analogical reasoning)
Stage 5: The teacher cautions the students about how the target differs from the familiar vehicle.
Stage 6: Students will be led in retrieval clues.

It should be noted that the last stage is an input of the researcher to make analogy instructional pedagogy model more meaningful and internalize learning in the classroom integration.

***Guide for Conventional Instuctional Strategy (GCIS):*** This was developed from the outline of classroom activities in the curriculum. The purpose is to give uniformity to the implementation of the conventional lecture instructional strategy; this can also be itemized in a step by step procedure according to Ajewole (1997) as follows;

- Teacher will introduce the concept.
- Teacher will discuss the facts or idea on the concept.
- Teacher will write note on the concepts on the chalkboard.
- Teacher will ask questions on the concepts.
- Teacher will give assignment to the students.

The face and content validity of CSPT and SSERS were ascertained.

The reliability of each instrument was established using test – retest method. The two instruments (CSPT, SSERS) were administered to thirty (30) senior secondary II chemistry students randomly selected from areas outside the selected areas for the study. The students, scores were obtained; items in these instruments were rearranged and administered again to the students two weeks after the first administration, to obtain another set of scores. This was done to ascertain if the scores will still be consistent with the scores obtained when the first administration of the instrument was carried out. The data found for each of the instruments were subjected to analysis using Pearson Product Moment Correlation formula to obtain the reliability coefficients of 0.84 and 0.86 for CSPT and SSERS

respectively, which were believed to be high enough for a research of this nature. Hence, the instruments were adjudged to be consistent, stable and reliable enough for use.

**Procedure**

The experimental procedure for this study was in three stages. The three stages of this study were followed: pre-treatment (one week), treatment (six weeks) and post-treatment (one week). All and all, the whole study lasted 8 weeks.

The teachers who severed as research assistants were educated on the roles they were expected to play in the course of the study and thoroughly trained on the use of the instructional packages.

The teachers in the two groups involved in this study were also enlightened on how to carry out the pre-test and post-test on the concerned students in order to obtain reliable and accurate results for each tests. The research instruments (CSPT and SSERS) given as pre-test were administered on the students at the end of the first week before the commencement of treatment on the students in the two groups.

Students in experimental groups (interactive-engagement and analogy-enhanced) were exposed to the treatment. During this stage, students in the experimental groups were taught the main concepts of the hydrocarbons alkane, alkene, alkyne and aromatic hydrocarbon using the interactive-engagement and analogy-enhanced instructional strategies for six weeks. Similarly, the same concepts were presented to the students in the control group through conventional strategy.

The post-test was thereafter administered on students in the experimental groups and the control group, immediately after the completion of the treatment. The same research instruments (CSPT and SSERS) given to the sampled students as pre-test were re-arranged (This was done to eliminate the prospect of students memorizing pre-test information and thereby discourage transfer of information from pre-testing to post-testing) and administered on them again as post-test to find out levels of their performance and self-efficacy in Chemistry respectively.

The data gathered were analysed using Analysis of covariance (ANCOVA). The hypotheses were tested at 0.5 level of significance.

**Results**

***Hypothesis One***

There is no significant effect of school location, interactive-engagement and analogy-enhanced strategies on the students' performance in Chemistry.

To test hypothesis one, the performance mean scores of Chemistry students exposed to interactive-engagement, analogy-enhanced strategies and the conventional method in urban areas and rural areas were computed and subsequently compared for statistical significance using Analysis of Covariance (ANCOVA) at 0.05 level of significance. The result is presented in Table 1.

**Table 1:** ANCOVA Showing Students' Performance in School Location by Treatment

| **Source** | **SS** | **Df** | **MS** | **F** | **P** |
|---|---|---|---|---|---|
| Corrected Model | 2091.546[a] | 6 | 348.591 | 88.056 | .000 |
| Covariate(Pretest) | 11.106 | 1 | 11.106 | 2.805 | .096 |
| Location | 1.589 | 1 | 1.589 | .401 | .527 |
| Group | 1302.310 | 2 | 651.155 | 164.486 | .000 |
| Location * Group | 1.642 | 2 | .821 | .207 | .813 |
| Error | 756.116 | 191 | 3.959 | | |
| Total | 96797.000 | 198 | | | |
| Corrected Total | 2847.662 | 197 | | | |

**P>0.05**

Table 1 reveals that there is no significant effect of school location on performance mean scores students exposed to interactive-engagement, analogy-enhanced strategies and the conventional strategy in Chemistry at 0.05 level of significance ($F_{2,191}$= 0.207; p>0.05). The null hypothesis is not rejected. Similarly, the effect of school location on students' performance in Chemistry is not significant at 0.05 level ($F_{1,191}$= 0.401; p>0.05). However, the effect of treatment on students' performance in Chemistry is statistically significant at 0.05 level ($F_{2,191}$= 164.486; p<0.05).

**Hypothesis Two**

There is no significant effect of school location, interactive-engagement and analogy-enhanced strategies on secondary school students' self-efficacy in Chemistry.

The Chemistry Self-efficacy mean scores of students exposed to interactive-engagement, analogy-enhanced strategies and the conventional strategy in urban areas and rural areas were computed and subsequently compared for statistical significance using Analysis of Covariance (ANCOVA) at 0.05 level of significance in order to test hypothesis two. The result is presented in Table 2.

**Table 2:** ANCOVA Showing Students' Self-Efficacy in School Location by treatment

| Source | SS | df | MS | F | P |
|---|---|---|---|---|---|
| Corrected Model | 17626.907 | 6 | 2937.818 | 191.971 | .000 |
| Covariate(Pretest) | 28.071 | 1 | 28.071 | 1.834 | .177 |
| Location | 4.694 | 1 | 4.694 | .307 | .580 |
| Group | 9562.475 | 2 | 4781.238 | 312.429 | .000 |
| Location * Group | 68.068 | 2 | 34.034 | 2.224 | .111 |
| Error | 2922.957 | 191 | 15.303 | | |
| Total | 751099.000 | 198 | | | |
| Corrected Total | 20549.864 | 197 | | | |

**p>0.05**

Table 2 shows that there is no significant difference in the self-efficacy mean scores of rural and urban students exposed to interactive-engagement, analogy-enhanced strategies and the conventional strategy in Chemistry at 0.05 level of significance ($F_{2,191}$= 2.224; p>0.05). The null hypothesis is not rejected. Also, the main effect school location on students' self-efficacy in Chemistry is not significant at 0.05 level ($F_{1,191}$= 0.307; p>0.05). However, treatment had significant effect on students' self-efficacy in Chemistry ($F_{2,191}$= 312.238; p<0.05).

**Discussion**

The study found that there was no significant location effects on the performance students in chemistry of the interactive-engagement and analogy-enhanced strategies. This finding is in harmony with the work of Kolawole and Popoola (2011), who found that the mean achievements of rural and urban students in mathematics are not statistically different when they study the four ability process dimension (4APD) in function of improving the teaching and learning of mathematics. This is also further buttressed by the submission of Fans and Chen (2005) that, the academic performance of rural and urban school students when subjected to the same treatment does not vary substantially. Williams (2005) also noticed that the average achievement score of urban and rural school students subjected to computer-assisted-instruction in chemistry was not significantly different. However, Adebule and Aborisade (2013) in their own study submitted that students in urban schools perform better than their counterparts from rural schools. Also, Owoeye and Yara (2011) and Onah (2011) also share same view in their separate studies, when they submitted that students in urban school have a better performance than their counterparts from rural schools.

The reason for this is not far-fetched from the interactive nature of the strategies which give room for healthy interaction between the teacher and the learners. Also, various learning experiences are brought into the classroom for the students to gain new learning experiences. These strategies are learner-centred and as such encourage students' active participation in classroom activities and critical thinking.

The result of the study also revealed that there was no significant location effect on students' self- efficacy in Chemistry when exposed interactive-engagement, analogy-enhanced and the conventional strategies. The finding supported Dalgety and Call (2006) who opined that location and environment help students to interact effectively and positively, hence enhanced self-efficacy. However, the finding contradicted the views of other researchers such as Owoeye and Yara (2011) and Onah (2011) who share the belief that location influences the students' self-efficacy. Owoeye and Yara (2011) and Onah (2011) in their separate studies concluded that students in urban

schools have better self-efficacy than their counterparts in rural schools when exposed to many laboratory materials and practical skills in Chemistry.
It is important to note that unnoticeable effect of school location on students' self-efficacy when exposed to interactive-engagement and analogy-enhanced strategies could have been possible due to students' involvement in the learning activities which makes the lesson interactive and fascinating. They tend to develop positive self-perception when the lessons become interesting and interactive.

**Conclusion**

Base on the findings of the study, it is concluded that students' school location does not contribute to students' academic performance in Chemistry when exposed to interactive-engagement and analogy-enhanced strategies. The effectiveness of interactive-engagement and analogy-enhanced strategies are not limited by where the students' schools are located. Also, it was concluded that school location has no effect on the students' self-efficacy when exposed to interactive-engagement and analogy-enhanced strategies. Students' self-perception of their own ability to perform well was equally improved on and does not differ by their school location.

**Recommendation**

The following recommendations were provided on the basis of the results of the study;

1. Chemistry teachers should embrace the innovative instructional strategies by deliberate use of interactive-engagement and analogy-enhanced instructional strategies in the learning process in order to facilitate better self-efficacy and higher performance of students' in Chemistry.
2. Seminars and workshops should be organized by schools for students to promote the development of positive self-efficacy in Chemistry
3. The government also should organize workshops to train teachers on the use of these new innovative strategies.

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