



# The Effects of Analogy on Male and Female Chemistry Students' Problem-Solving Ability in Electrolysis

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## Abstract

Studies have shown that Nigerian secondary school chemistry students have difficulty solving problems involving electrolysis and other concepts. The study was carried out to find out the comparative effects of analogy on male and female students' problem solving ability in electrolysis. The pretest-posttest-control group design was employed. Three instruments, Chemistry Achievement Test (CAT), Mathematical Skill Test (MST) and Chemistry Problem Solving Test (CPST) were developed and used. The CAT and MST were used alongside the pretest and randomization of the sample to ensure equality of the groups. Sixty four students were randomly selected, pre-tested and assigned into control and analogy (experimental) groups. The control group was taught using lecture method while the experimental group was taught using analogy. Analyses of students' posttest mean scores in the CPST using t-test ( $\alpha = 0.05$ ) showed that students taught with analogy performed better than those in the control group in a chemistry problem solving test involving electrolysis. There was also a statistically significant difference between the posttest mean scores of male and female students in a CPST involving electrolysis when they were taught using analogies. The male students performed better than the female students. The study recommended the use of analogies as strategies for teaching problem solving tasks in electrolysis especially to male students.

**Keywords:** Analogy, Problem-solving, Electrolysis, Chemistry, Strategies.

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## INTRODUCTION

Science and technology have always been recognized as the basic tool of industrialization and national development and could bring economic and social happiness by providing employment and improving the welfare of the citizenry. As a matter of fact, discoveries in information technology have reduced the world to a global village with the World Wide Web being an enormous information base (Oak, 2011). In Nigeria, some provisions of the National Policy on Education and the change to the 9-3-4 system all aim at providing sufficient opportunities are opened to citizens to get the best scientific education possible.

Chemistry has played a major role in science, technology and society, and it still does so today. There is hardly found anything in nature that chemistry does not have an influence or impact over. No wonder the assertion that without chemistry there will be no life. Unfortunately, the subject has always come under threat with low performance by secondary school students in Nigeria.

A number of studies such as Jimoh (2004) and Njoku (2007) amongst others have reported the poor performance of chemistry students at the secondary and tertiary levels over the years. The National Examination Council (NECO) revealed that the percentage credit pass of students in chemistry during the November/December General Certificate of Education examination for 2011, 2012 and 2013 as 5.32%, 30.17% and 66.41% respectively (Mosadomi, 2014). A source from the West African Examination Council (2012) gives the percentage credit pass in chemistry as follows: 2007 (45.96%), 2008 (44.44%), 2009 (43.70%), 2010 (50.70%) and 2011 (49.54%).

Various reasons have been given for students' poor performance in chemistry amongst which is their inability to solve chemical problems (Dajuma, 2005). Some of the concepts that present such difficulty to students include electrochemistry, chemical equilibrium, redox reactions, mole concept and stoichiometry. However, most researchers attribute the poor performance of students in chemistry and problem solving ability to the pedagogical approaches adopted by teachers in schools (Gabel, 2003; Mtsem, 2011; Owolabi & Oginni, 2013). The poor problem solving ability of students points to a likely deficiency in method of instruction and neglect of students' centered learning strategies. Metacognitive instructional strategies have emerged as a result of various researches and have been found to assist in this direction (Orgil & Thomas, 2007). One of these metacognitive instructional strategies is the use of analogies.

An analogy is a comparison between two domains of knowledge: one that is familiar and another that is not (Orgil & Bofner, 2004). The familiar one is called the analog while the unfamiliar one is the target domain. The target is what needs to be learnt. Researchers in science education have identified analogy as a powerful tool for explaining and facilitating an individual's construction of knowledge (James, Scharmann & Lawrence, 2007). However, despite the effectiveness of these student-centered strategies, little is understood about the effect of analogies on male and female students' performance in problem-solving tasks involving the electrolysis. How will the male and female students differ in their problem-solving ability in electrolysis when taught using analogies?

### Objective of the Study

The main purpose of this study was to find out the comparative effects of analogy on male and female students' problem solving ability in electrolysis. Specifically, the study sets to:

- Find out if the male and female students differ in their chemistry problem solving ability in tasks involving electrolysis before being taught the concepts;

- Find out if male and female students taught with analogy teaching strategy differ in their problem solving ability in tasks involving electrolysis.

Two null hypotheses were formulated and tested during the study:

- There is no significant difference between the pretest mean score of male and female students in a chemistry problem solving test involving electrolysis;
- There is no significant difference between the posttest mean scores of male and female students in a chemistry problem solving test when taught electrolysis using analogy instructional strategy.

## METHODS

### Research Design

The study was a pretest-post-test control group design. The main strength of this design is that the initial random assignment of subjects to the groups and the administration of a pretest to all the groups help to control all threats to internal validity. It also ensures that both groups are equivalent on all important dimensions and that there are no systematic differences between the two groups. The design also controls all the threats to internal validity. The purpose of the experiment was to show that any difference obtained between the initial scores and the final scores in the groups were as a result of the different treatment received by each group.

### Sampling/Data analyses

The sample for the study (consisting of sixty four male and female students) was arrived at through random sampling after administering CAT and MST. The data analyzed was obtained through the administration of a chemistry problem solving test, CPST. The reliability coefficient of the CPST was found to be 0.87. Those of the CAT and MST were 0.80 and 0.93 respectively. The t-test for independent sample was used to analyze the data.

The students were grouped into two classes of thirty two students each, one the control and the other the experiment (analogy) class.

## RESULTS

The pre-test mean scores of the male and female students were analyzed and the results used to answer research question one and to test hypothesis one as follows:

Table 1a: Group statistics of pretest of male and female students in CPST

| Test Group | N  | Mean  | S.D   | S.E<br>Mean |
|------------|----|-------|-------|-------------|
| Male       | 32 | 27.63 | 1.786 | 0.258       |
| Female     | 32 | 27.10 | 2.080 | 0.300       |

**Research question one:** What is the difference between the pretest mean scores of male and that of female students in a chemistry problem solving test?

The results as presented in tables 2a and 2b show that the pretest mean score of the male students was 27.63 while that of the female students was 27.10. The mean difference between the two was 0.53, a negligible figure.

Table 1b: Independent sample test for equality of pretest means of male and female students in CPST

| Group         | Mean diff. | t     | df | S.E diff | P – sig (2-tailed) |
|---------------|------------|-------|----|----------|--------------------|
| Male & Female | 0.53       | 0.421 | 62 | 0.396    | 0.675              |

**Hypothesis one:** There is no significant difference between the pre-test mean score of male students and that of female students in a chemistry problem solving test.

The p-significant value was found to be 0.675 ( $p > 0.05$ ). This means that there was no statistically significant difference between the pretest means score of the male students and that of the female students. Therefore the null hypothesis one was accepted. The researcher analyzed the posttest scores of the students and presented it appropriately.

**Research question Two:** What is the difference between the post test mean scores of male and female students in a chemistry problem solving test when taught using analogy instructional strategy?

Table 2a: Group statistics of posttest of male and female students in CPST

| Test Group | N  | Mean  | S.E   | Mean diff |
|------------|----|-------|-------|-----------|
| Male       | 16 | 66.00 | 0.593 | 6.60      |
| Female     | 16 | 59.40 | 0.518 |           |

The results analyzed and presented in tables 3a and 3b showed that the posttest mean scores of male and female students taught with analogy are not the same. While the male students in the analogy group had a mean score of 66.00, the female students in the same analogy group had a mean score of 59.40. The mean difference was 6.60, the mean scores of male students being higher than females’.

Table 2b: Independent sample test for equality of posttest means for male and female students in CPST

|                        | Mean diff. | t     | df | S.E diff | P – sig (2-tailed) |
|------------------------|------------|-------|----|----------|--------------------|
| Equal variance Assumed | 6.60       | 2.539 | 30 | 0.788    | 0.017              |

**Research hypothesis Three:** There is no significant difference between the posttest mean scores of male and female students in a chemistry problem solving test when taught using analogy instructional strategy

The p-value,  $0.017 < 0.05$  as presented in table 2b. This showed that the mean score of male students in the CPST when taught with analogy differed significantly from that of the female students. The null hypothesis was rejected and the alternate hypothesis accepted. Therefore, there is a significant difference between the posttest mean scores of male and female students in a chemistry problem solving test when taught using analogy instructional strategy.

## **Discussion of Results**

There was no statistically significant difference between the pretest mean scores of male students and female students in a chemistry problem solving test task involving electrolysis. This was to be expected as both groups were equivalent given the mode of selection of the sample.

The study also revealed the existence of a statistically significant difference in the posttest mean scores of male and female students in a chemistry problem solving test task involving electrolysis when both were taught using analogies. This finding showed that male chemistry students benefitted more in problem solving task involving electrolysis when taught using analogy than female students – indicating gender influence. The reasons for this may include male students' better reasoning ability and high level of abstract thinking, exposure of males than female to the environment, restrictions on females due to customs and religious beliefs which reduce their exposure, etc. The life-world experience of male students helped them visualize abstract ideas than females.

The finding here agrees with (Eribe & Ande, 2006) who found out that there exists gender difference or inequality in science achievement among secondary school science students and that of (Onekutu, 2002) who found out that male students performed better than females with an increasing gap in chemistry examination. Adesoji and Babatunde (2008) reported that female students encountered problem solving difficulties more frequently than their male counterparts. The result is inconsistent with Armagan, Sagir and Celik (2009), who reported that female students did better than male students when they investigated the effect of problem solving skills on the achievement chemistry students. It also disagreed with Olorundare and Aderogba (2009) who reported that there was no significant difference between the academic performance of male and female students exposed to treatment with analogy (but problem solving in electrolysis)

## **CONCLUSION**

Based on the findings of the study, male students benefit more than female students in chemistry problem solving test when analogy is used to teach the concept of electrolysis. This may be due to the ability of male students to think abstractly than the females. The reasoning ability of males is usually higher than that of females hence the males think and relate to the analogy more easily than females.

## **Recommendations**

The result of this study has implication for the teaching and learning of chemistry in secondary schools. The findings show that teaching strategies influence the performance of students in problem solving tasks involving electrolysis. Chemistry teachers' training programs should include a deliberate preparation of teachers for the acquisition of skills in the use of analogy strategies that are useful in this direction. Education authorities and professional bodies should organize seminars, workshops, refresher courses and conferences on the relevant use of analogies as an instructional strategy on regular basis for teachers.

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