# African Research Review

## Effects of Reformulation of Knowledge and Expository Teaching Strategies on Students' Performance in Chemistry

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### Abstract

*This quasi-experimental study conducted in 2 co-educational secondary schools in Uyo Local Government Area of Akwa Ibom State, Nigeria investigated the effectiveness of reformulation of knowledge teaching approach in facilitating students' achievement in chemistry compared with the traditional expository method considering their gender differences. Two research questions and two hypotheses guided the study. The sample consisted of 96 students (51males and 45 females). The instrument for data collection was a 25-item multiple choice questions – Chemistry Achievement Test (CAT) – with a reliability index of 0.72. Validated researcher-made instructional packages on reformulation and expository methods were used in teaching the concept of properties and reactions of water to the subjects in their intact class setting. The results of analyses of data using Analysis of Covariance (ANCOVA) showed that those taught using reformulation of knowledge approach performed significantly better than those taught using the expository method; and that gender is not a significant determinant of students' performance in chemistry. Consequently, it was recommended that chemistry teachers should make effective use of this approach in teaching chemistry concepts in view of its high facilitative effect.*

### Introduction

Students in Nigerian secondary schools have difficulties in learning certain concepts in chemistry. They seem to be reasonably happy with their ability to write chemical symbols and formulae, but are less confident about solving

problems that involve numbers or abstract concepts. This is indicated in their persistent poor performances in chemistry examinations conducted by external bodies such as West African Examinations Council (WAEC) (Osokoya, 2003; Ibraheem, 2004).

Prominent among contributors to students' persistent poor performances or underachievement in chemistry are:

1. Ineffective teaching methods or approaches adopted by science teachers (Njoku, 2004).

2. Learners' variables such as gender stereotyping, poor attitude to the subject and low numerical ability (Okeke, 2003; Ubom, 2003).

The unique nature of chemistry seems to give the learners multiple problems. Chemistry, as a branch of science, does not only deal with fundamental questions on the structure of matter and the interactions of the elementary constituents of matter, which are susceptible to experimental investigation and theoretical inquiry, but also study chemical concepts such as solvability, electrolysis and redox reactions which are abstract. The difficulty, therefore, is also attributed to the abstract nature of such topics.

Unfortunately, studies show that Nigerian classrooms are still dominated by ineffective and inappropriate teacher-centered teaching methods such as the expository and teacher centered-demonstration approaches (Njoku, 2004). The difficulties experienced by the learners cannot be resolved through these methods but through use of appropriate student-centered methods as the reformulation of knowledge or conceptual change teaching approach.

Reformulation of Knowledge teaching strategy is a constructivist teaching approach with great potential for enhancing the teaching and learning of all chemistry concepts at all levels of education in Nigeria and other countries of the world. It is based on the assumption that, new learning becomes meaningful if it can be linked with the learners' previous cognitive structures (Eniayeju, Eniayeju & Lapkini, 2004). Put simply, 'reformulation of knowledge' refers to re-enforcing what one had already learnt through re-telling it to others, or verbalizing associations between what one knew before and after the concept had been elaborated upon (Cullen & Sato, 2000).

This strategy, which was developed for enhancing students' problem-solving ability, is rooted in Piaget's theory of intellectual development (Redish,

1998). According to Inyang (1993), two invariant processes – organization and adaptation - are involved in the functioning of the human intellect. Organization involves integrating experiences from several senses; and adaptation involves assimilating or incorporating the various experiences into already existing cognitive structures. Students construct and reformulate knowledge as they engage in new experiences in order to internalize the concepts learnt.

Previously, learning was considered as the process of accumulating information or experiences, and prior knowledge was considered the bane of transmission of knowledge. However, Roschelle (1995) observed that learners' prior knowledge often confounds educators' best efforts to deliver ideas and concepts accurately, since learning proceeds primarily from prior knowledge and only secondarily from newly presented materials. That is, prior knowledge can be at odds with the new materials, and its neglect can result in the audience learning something opposed to the educators' intentions, no matter how best those intentions are executed. It is worthy of note that, new knowledge hardly replaces prior knowledge , rather, it re-uses it, thereby making it possible for it to be refined and placed in a more encompassing structure (Roschelle, 1995).

According to Redish (1998), reformulation of knowledge teaching and learning approach is based on the following principles:

- **The Constructivism Principle** – This principle asserts that what people construct depends on the context and their mental states; hence learners must find a body of knowledge relevant to be able to incorporate into their cognitive structures.

- **The Change Principle** – This principle asserts that producing significant change in a well-established pattern of association is difficult, but can be facilitated through a variety of known mechanisms.

- **The Distributive Function Principle** – This principle asserts that individuals show limited, but significant variations in their styles of learning along a number of dimensions.

- **The Social Learning Principle** – This principle asserts that, for most individuals, learning is most effectively carried out through social interactions.

Based on these principles, the following three phases are involved in reformulation of knowledge lessons:

### Phase 1: Initial Association with the concept

At this phase, students brainstorm on what they know about the concept or key vocabularies and listen to their classmates' associations. This activity allows the learners to think through what they already know about the concept and set stage for more critical analysis of the content.

### Phase 2: Reflection on the Initial association

Here the learners are guided to reflect on their initial association with questions such as, 'What made you think…?' or 'Why did you think…?'

### Phase 3: Reformulation of Knowledge

After discussions in phase two, and before presentation of the new concepts, the teacher gives the learners the opportunity to verbalize associations that had been elaborated upon or changed.

The following three response levels are expected at this phase:

### First Level Responses

Responses at this level indicate much prior knowledge about the concept or topic to be presented. The responses are of the main idea-type concepts, definitions, analysis or linkages of on concept or another.

### Second Level Responses

Responses at this level indicate some prior knowledge about the concepts in terms of examples, attributes or characteristics. Such responses show that the learners should be able to comprehend the concepts with some guidance by the teacher.

### Third Level Responses

The responses at this level indicate that the learners have just little prior knowledge of the concept or topics to be presented. That is, the knowledge they have is not enough to establish connections with the topics; hence, there is need for additional information to fill the gap in prior knowledge in order to understand the concepts. Based on the level of responses from the learners, the teachers can then decide on what next to do – provide background information or proceed to concept development?

### Statement of the Problem

Students' performances in chemistry, at both internal and external examinations, in Nigeria are persistently poor. Studies (Okeke, 2003; Ubom,

2003; Njoku, 2004) blame this monster, mostly, on the teaching approaches used by the teachers, and students' variables. The problem of this study is to determine how effective reformulation of knowledge teaching approach could be in facilitating students' achievement in chemistry considering their gender differences. Presently there is paucity of studies in this area especially in the Nigerian scene.

**Research Questions**

The study provides answers to the following research questions:

1. How do students taught using reformulation of knowledge teaching approach differ in their performance in chemistry when compared with those taught using the conventional teacher-centered expository method?

2. How do male and female chemistry students differ in their performances in chemistry when taught using reformulation of knowledge and expository teaching methods?

**Research Hypotheses**

The study tested the following null hypotheses:

1. There is no significant difference between the performance of students in chemistry when taught using reformulation of knowledge and when taught using expository teaching methods.

2. There is no significant difference between the performance of male and female students in chemistry taught using reformulation of knowledge and those taught using expository teaching method.

**Methodology**

The study used non-randomized pretest-posttest control group design structurally represented as:

$$E: 0_1 \; x \; 0_2$$

$$C: 0_3 \; . \; 0_4$$

Where:

$0_1$ and $0_3$ are pretest observations for experimental and control groups respectively;

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$0_2$ and $0_4$ are posttest observations for experimental and control groups respectively;

X is teaching with reformulation of knowledge approach; and

. is teaching with expository teaching method.

A sample of 96 Senior Secondary II (SSII) chemistry students drawn from two intact classes in two co-educational public secondary schools in Uyo Local Government Area of Akwa Ibom State of Nigeria using criterion sampling technique was used for the study.

The instrument used in collecting data was a researcher-developed 25-item 4-option multiple choice test - the Chemistry Achievement Test (CAT) - designed to measure students' achievement in the area of properties and reactions of water. The test had a reliability index of 0.72 determined using test-retest approach. Each correct answer was scored 4 marks, and incorrect answers, 0 (zero). Hence, the maximum score was 100 and minimum zero.

The researcher used the subject teachers in the selected schools as research assistants after duly training them for the purpose using the validated instructional package developed by the researcher. The research assistants, after administering CAT as pretest, taught the students in their respective groups, using instructional packages from the researcher in their intact class setting and during the normal chemistry periods.

The experimental group was taught properties and reactions of water using reformulation of knowledge approach while the control group was taught the same concept using the conventional teacher-centered expository approach. The assistants administered the reshuffled version of CAT as post-test after treatment. The classroom investigation lasted for 2 weeks. Both the teaching of the concepts and the administration of the pre-test and post-test were strictly supervised by the researcher. The pre-test and post-test scripts were collected immediately after each test by the research assistants and handed over to the researcher for marking. The data obtained were analyzed using Analysis of Co-variance (ANCOVA).

**The Results**
**Research Questions**
The results in Table 1 were used in answering the 2 research questions raised.

In Table 1, the mean scores of the students in the experimental group on post-test and pre-test are 53.92 and 31.10 respectively. These results give a post-test - pre-test mean difference of 22.82. The mean scores of the students in the control group on post-test and pre-test are 50.89 and 33.62 respectively, giving a post-test - pretest mean difference of 17.27. The gain in scores show that the students in the experimental group taught by reformulation of knowledge approach (22.82) performed better than their counterparts in the control group who were taught with expository method (17.27). Considering research question one - How do students taught using reformulation of knowledge teaching approach differ in their performance in chemistry when compared with those taught using the conventional teacher-centered expository method? – the observations indicate that students taught by using reformulation of knowledge teaching approach did better than those taught with the conventional teacher-centered expository method.

With respect to performance by gender, Table 1 shows that the gain in mean scores of the males in the experimental group was 22.60 while that of their female counterpart in the same group was 23.09. However, with respect to gender performance of those in the control group the gain in mean of males and females were 16.00 for males and 18.61 for females. These indicate that the females in both reformulation of knowledge and control groups benefited more from the instructions given than their male counterparts. Considering research question two – How do male and female chemistry students differ in their performances in chemistry when taught using reformulation of knowledge and expository teaching methods? – these observations showed that the achievement of the students by gender was in favour of the females irrespective of the teaching strategy used.

**The Hypotheses**
The two hypotheses formulated were tested using the results in Table 2.

In Table 2, the calculated F-ratio for the main effect of instructional strategy at df 1, 91 is 32.47, while its corresponding significant level is .00 alpha. This significant level is less than .05 alpha, indicating that the instructional strategies adopted had significant effect on the achievement of the students in chemistry. Hence, hypothesis 1: There is no significant difference between the performance of students in chemistry when taught using reformulation of knowledge and expository teaching methods. - was rejected.

As regards the direction of significance, a post-hoc analysis using t-test was done and the results displayed in Table 3 showed that, with an observed t

value of 2.38 as against the critical value of 1.98 at df 94 and p= 0.05 alpha, those taught by reformulation of knowledge performed significantly better than those taught using expository teaching method.

With respect to Hypothesis 2: There is no significant difference between the performance of male and female students in chemistry taught using reformulation of knowledge and those taught using expository teaching method - the results in Table 2 showed that the calculated F-value for the main effect of gender at df 1, 91 is 0.49 while its corresponding significant level is 0.49 alpha. The observed significant level, 0.49 alpha is greater than 0.05 alpha in which the decision is based. This indicates that the influence of gender on students' performance in chemistry is not statistically significant. Hence, hypothesis 2 was upheld.

**Discussion**

This study investigated the effectiveness of reformulation of knowledge teaching approach in facilitating students' achievement in chemistry compared with the traditional expository method considering their gender differences. The results in Tables 2 and 3 showed that students taught using reformulation of knowledge performed significantly better than those taught using the traditional expository method. The better performance of students taught using reformulation of knowledge is explained in terms of its ability to re-use the students' prior knowledge thereby making it possible for it to be refined and placed in a more encompassing structure (Roschelle, 1995).

On gender effect, hypothesis 2 predicted that there is no significant difference in the achievement of male and female students in chemistry when taught using reformulation of knowledge and expository teaching methods. The findings from the results on Table 2 supported this prediction, hence the hypothesis was upheld. The comparable performance of the males and females observed indicated that gender is not a strong determinant of students' academic achievement in chemistry.

**Conclusion**

Consequent upon the findings from this study, it is hereby concluded that reformulation of knowledge has a greater enhancing effect on students' performance than the traditional expository method and that students' achievement in chemistry is significantly dependent on teaching strategy adopted rather than gender differences among students.

### Recommendations

Based on the observations made, it is recommended that Chemistry teachers should not at any time overlook the students' prior knowledge but adopt the reformulation of knowledge teaching approach in teaching chemistry concepts in view of its high facilitating effect on students' performance through its ability to re-use and refine the students' prior knowledge for better understanding of the concepts taught. Also, parents and teachers should play down on the issue of gender on students' academic performance as evidences show that it is not a significant determinant of students' achievement in science.

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**Table 1:** A comparison of pretest – post-test mean score of students on CAT classified by treatment and gender

| Variable + Category | Sample Size | Pretest | | Post-Test | | Mean Difference (Posttest – Pretest) |
|---|---|---|---|---|---|---|
| | | Mean | Dev'n | Mean | Dev'n | |
| **Reformulation** | | | | | | |
| Male | 27 | 31.70 | 8.73 | 54.30 | 6.49 | 22.60 |
| Female | 22 | 30.36 | 8.77 | 53.45 | 7.15 | 23.09 |
| **Total** | **49** | **31.10** | **8.77** | **53.92** | **6.73** | **22.82** |
| **Expository** | | | | | | |
| Male | 24 | 35.50 | 7.94 | 51.50 | 5.82 | 16.00 |
| Female | 23 | 31.65 | 6.02 | 50.26 | 5.50 | 18.61 |
| **Total** | **47** | **33.62** | **7.25** | **50.89** | **5.64** | **17.27** |
| | | | | | | |
| **Total:** Male | 51 | 33.49 | 8.50 | 52.98 | 6.28 | 19.49 |
| Female | 45 | 31.02 | 7.54 | 51.82 | 6.49 | 20.80 |
| **GRAND TOTAL** | **96** | **32.33** | **8.12** | **52.44** | **6.37** | **20.11** |

**Table 2:** Summary of Analysis of Covariance (ANCOVA) of student's post-test performance classified by treatment and gender with pre-test as covariate

| Source of variation | Sum of squares | Df | Mean Square | F-cal | Sig. | Decision at p<.05 level |
|---|---|---|---|---|---|---|
| Covariate: Pre-test | 2253.74 | 1 | 2253.74 | 151.05 | .00 | Significant |
| Main Effects: | | | | | | |
| Instructional Strategy | 145.89 | 1 | 484.50 | 32.47 | .00 | Significant |
| Gender | 16.36 | 1 | 7.31 | .49 | .49 | Not Significant |
| 2-way interaction | | | | | | |
| Instructional Strategy * | | | | | | |
| Gender | 1.85 | 1 | 7.85 | .53 | .47 | Not significant |
| Residual | 1357.78 | 91 | 14.92 | - | - | - |
| Total | 3857.63 | 95 | - | - | - | - |

**Table 3:** Summary of t-test comparison of students' post-test performance classified by       treatment

| Variables Decision | n | Mean | SD | t | df | t-crit |
|---|---|---|---|---|---|---|
| Reformulation of Knowledge significant | 49 | 53.92 | 6.73 | 2.38 | 94 | 1.98 |
| Expository Method | 47 | 50.89 | 5.64 | | | |