

## Effect of Practical Chemistry Teaching Strategies on Students' Acquisition of Practical Skills in Secondary Schools in Kogi State

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### Abstract

One of the problems confronting Chemistry teachers during practical work is large class size and inadequate number of equipment needed for each student. Many Chemistry teachers have had to divide their class into two or more sessions thereby increasing the workload on the teachers and laboratory personnel. Among the teachers in our neighbourhood, there have been arguments as to whether students working in groups are better in achievement than those working as individuals during practical Chemistry. This study was designed to compare the effect of practical Chemistry teaching strategies on students' acquisition of practical skills. The design of the study was quasi-experimental design. Specifically, the non-equivalent group design was used. The study was carried out in secondary schools in Ankpa Education zone, of Kogi state, Nigeria. Two research questions and three null hypotheses guided the study. A sample of 84 Senior Secondary III Chemistry students from two intact classes in two secondary schools participated in the study. The instrument for data collection was Chemistry Practical Skill Rating Scale (CPSRS). Data collected for the study were analyzed using mean and standard deviation while Analysis of Covariance (ANCOVA) was used to test the hypotheses at  $p < 0.05$  level of significance. The results revealed that students' group work strategy significantly enhanced their acquisition of Chemistry practical skills, compared to individual laboratory work strategy. Gender did not significantly influence students' acquisition of Chemistry practical skills. Treatment by gender interaction effect was not significant at 5% alpha level. Based on these findings it was recommended, among others, that Chemistry teachers should adopt group work as often as possible during Chemistry practical work at secondary school level.

### Introduction

Chemistry is the study of the structure of matter, its transformations, interactions and energy consequences of the changes matter undergo (Njoku, 2009). Chemistry is studied for acquisition of knowledge and skills about matter in order to improve the world around us. Effective teaching and learning of Chemistry in Nigerian schools is therefore desirable. However, Chemistry teaching and learning in most Nigerian schools do not proceed as desired. This is because students' performance is perennially poor in Chemistry external examinations. The trend in the academic performance of Chemistry students in senior secondary school examinations (SSCE) has not been encouraging (Ajagun, 2006). The West African Examination Council (WAEC) Chief Examiner's reports for senior secondary certificate examination for the years 2000-2007, 2012, 2013, 2015 and 2016 identified that one of the reasons for poor performance of students in Chemistry is ineffective teaching method adopted by Chemistry teachers, as well as students' inadequate exposure to practical laboratory work. Njoku (2007) attributed students' differential performance in three aspects of practical chemistry examination, namely, (quantitative analysis, qualitative analysis and theory of practical questions), to the wrong ways and manner teachers teach practical chemistry.

Experience shows that Chemistry teachers often use individual laboratory strategies in which each student is given a set of equipment to carry out specific Chemistry practical activities.

Due to scarcity of chemicals and laboratory equipment sometime Chemistry teachers adopt group work for Chemistry practical activities. It is not yet clear whether individual or group work enhance students' achievement better.

Studies have reported disparity in the performance of girls and boys in chemistry. (Iyang and Ekpeyon, 2010). The influence of gender on students' performance in Chemistry practical skills acquisition was not significant. Raimi (2012) found that female students performed better than their male counterparts in computational skills involved in practical Chemistry. Babajide (2010) found that gender has no significant influence on students' achievement in science. By contrast, Ogunneye (2013), and Okwo & Otuban (2007) observed that gender has significant influence on Chemistry students' performance in class work and examinations. Since there is lack of clear trend in gender influences on students' acquisition of practical skills in Chemistry, it becomes necessary to investigate the joint influence of gender and grouping strategy during laboratory work on acquisition of practical skills among senior secondary school students. Group work is a way of getting students to work together to solve problems or learn new information/tasks. By using group work, students learn from one another's ideas and skills. Since scientist do not often work in isolation, using group work in a structured way can teach students skills in cooperation, which are similar to skills scientists must have to effectively operate in the scientific community. Cooperation in learning is an instructional strategy in which students work in small groups to accomplish common learning goals under the guidance of the teacher.

Individual laboratory work or students' individual hands-on-activity is when a student is given opportunity to personally work on learning tasks without necessarily involving other students. Teaching Chemistry requires more practical activities than verbal expository teaching if learners are to develop both intellectual knowledge and practical skills needed for problem solving. Chemistry teachers use both individual laboratory and group work as strategies in the teaching of Chemistry. The efficacy of these two strategies in students' acquisition of Chemistry laboratory/practical skills is not clear.

Teaching Chemistry in the Chemistry laboratory is more stimulating, enjoyable and productive to students than lecture method. Lecture method is teacher centred, and commonly adopted by many teachers due to ease of use and fast coverage of topics. It is archaic and no opportunity is given for individual activity, creative thinking, reasoning and construction of knowledge. When laboratories are well equipped with appropriate instruments, and students are taught laboratory activities and experiments, they invariably acquire the skills of the scientist which subsequently enable them compete with their counterparts anywhere they find themselves in the world. Teachers of Chemistry usually adopted laboratory method for teaching, although most often they lack the requisite equipment and other resources to work with. They often adopt individual laboratory work in preference to group work in the belief that individual work gives every student opportunity to handle the practical learning tasks personally. Most teachers adopt group work for Chemistry practical activities only when the required equipment and other resources are not enough to go round all the Chemistry students. This need not be the case if there is certainty that group work would be as effective as individual work since equipment and materials would be saved by adopting group work. Group work has other social learning advantages which are important objectives of education in general and science education in particular. For instance, group work enables learners to cooperate and tolerate one another, share ideas during problem solving activities which are often involved in Chemistry practical activities. On the other hand, individual work enable the student carry out the laboratory activities personally without having

to depend on other people. The individual worker has the opportunity to learn all the activities without distraction from class mates. The student in this case works at his/her own pace and may achieve greater mastery than group workers in chemistry laboratory activities. Thus both individual work and group work have their strengths and weaknesses. This study is therefore designed to compare the effects of individual and group laboratory activities on students' acquisition of Chemistry practical skills at secondary school level.

### Objectives of the study:

1. Ascertain the effect of individual laboratory work and group laboratory work on students' acquisition of Chemistry practical skills.
2. Ascertain the influence of gender on students' acquisition of Chemistry practical skills.
3. Ascertain any interaction effect of strategy and gender on students' mean scores in Chemistry practical skills.

### Research Questions

The following two research questions guided the study:

1. What are students' mean scores in Chemistry practical skills when taught using individual laboratory work and group laboratory work?
2. What are the male and female students' mean scores in acquisition of Chemistry practical skills?

### Hypotheses

The following three null hypotheses were tested at five percent level of significance.

- Ho<sub>1</sub>: Students' mean scores in acquired Chemistry practical skills do not depend on the use of group work or individual work teaching strategy ( $p < 0.05$ ).
- Ho<sub>2</sub>: Gender has no significant influence on the mean scores of students in acquisition of Chemistry practical skills ( $p > 0.05$ ).
- Ho<sub>3</sub>: There is no significant interaction effect of treatment and gender on the mean scores of students in Chemistry practical skills, ( $p > 0.05$ ).

### Methodology

The pre-test posttest quasi-experimental non-equivalent groups design was adopted for the study. The design is considered suitable because intact classes were used since randomization of subjects was not possible. The population for the study comprised all SSIII Chemistry students in Ankpa Education Zone of Kogi State, Nigeria. A sample of 84 SSIII Chemistry students from two intact classes of two secondary schools participated as research subjects in the study. The two treatment conditions were randomly assigned to groups. The two treatment conditions were teaching/ learning strategies: group work and individual work laboratory strategies. The researchers developed lesson plans on Chemistry practical activities - quantitative chemical analysis. The lesson plans were face validated by two experienced teachers in Chemistry. These lesson plans were used for teaching all the lessons needed in this study. For data collection, the researchers adopted an instrument, "the Chemistry Practical Skills Rating Scale (CPSRS)" earlier developed, validated and used by Njoku (1997). The CPSRS is a 5-point and 57-item rating scale. The 57 items of the scale are called behaviour categories which were unevenly distributed among eight sub-scales called skills categories. The skills categories include: Manipulative skills and conduct of experiment, Controlling extraneous variables, Measurement skills, Work habit, Safety skills, Inferring and Interpretation of observation or data, Mathematical Computation, and skills in observing, Recording of data and Communication skills.

During its development the CPSRS was pilot-tested and Kendal's Coefficient of Concordance (W) was used to determine the inter-rater reliability of the CPSRS. The value of (W) obtained was 0.55. The scale points include: Very Poor (VP), Poor (P), Fair (F), Good (G) and Excellent (E). These scale points correspond to weighted scores namely: 1, 2, 3, 4, and 5 respectively. As a five point observation scale, the CPSRS has a minimum score of 57 points while the maximum score would be 285. This scale can be used for rating the level of Chemistry practical skills exhibited by Chemistry students during practical activities in the Chemistry Laboratory. Before the experiment commenced, the research sample was observed and rated during practical activities session using (CPSRS). The rating scores obtained was used as the pretest scores for the study. After the pretest, group one (individual laboratory work group) was taught practical chemistry based on individual work strategy as in the lesson plans. This group is regarded as the conventional group method. The teaching was done by the trained research assistant, precisely the normal Chemistry teachers in the sample schools who had been trained on the effective use of the lesson plans prepared by the researchers. The duty of the teacher was to assist the researchers carry out the teaching using the prepared lesson plans, while the researchers supervised to ensure that procedures were followed at all times. The topics covered were on quantitative chemical analysis.

The second group, the group work strategy, on the other hand was taught the same topics on quantitative chemical analysis using group work strategy. There were 48 students per group of 5 giving a total of 10 working groups. The research assistant, the normal Chemistry teacher of the students in the school, was thoroughly trained in the use of this group work strategy. After teaching, both the individual work and the group work (comparison groups) were given a three hour practical test during which they were observed and rated by trained raters who used the CPSRS to record the levels of skills exhibited by the research subjects during the practical Chemistry work. The duration of the practical test was deliberately extended to ensure that the research subjects completed all the items of the test, and the raters rated their skills on all the sections and behaviour categories of the CPSRS. The data obtained from the rating of the research subjects were analyzed to answer the research questions and test the hypotheses. The statistics involved in the data analysis were mean and standard deviation of scores for answering the research questions, while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 5% level of significance.

## Results

The results are presented according to research questions and hypotheses:

**Table 1:** Mean rating scores and standard deviation of scores of the two treatment groups of students on CPSRS

Groups	N	Pretest		Posttest		Mean gain score	Mean gain diff
		$\bar{X}$	SD	$\bar{X}$	SD		
Students' Group Work	48	90.33	25.72	174.04	20.68	83.71	
Individual Laboratory Work	36	88.92	29.59	153.83	25.27	64.92	18.79

Result in Table 1 shows the mean practical skills scores of students taught using individual laboratory work and those taught using group works. Students exposed to group work had a pre-test practical skills mean score of 90.33 with standard deviation of 25.72 and a post-test mean score of 174.04 with standard deviation of 20.68. The mean gain score is 83.71. The standard

deviation (SD) of the students in group work condition reduced from 25.72 in the pretest to 20.68 in the posttest. This shows that more students had scores that are closer to the mean in the posttest than in the pretest. Since the mean score of this group is very high in the posttest compared to the pretest, the treatment caused general increases in the scores of the students. On the other hand, students exposed to individualized laboratory work treatment condition had a practical skills pretest mean score of 88.92 with standard deviation of 29.59 and post-test mean score of 153.83 with standard deviation of 25.27. The mean gain is 64.92. The mean gain difference in score is 18.80 in favour of students taught under group work condition. The difference in mean score is apparently large. The result indicates that teaching Chemistry practical activities using group work strategy tends to enhance students' acquisition of more practical skills when compared with teaching with individualized laboratory work strategy. It should be noted that SD of the individual practical work condition reduced from 29.59 to 25.27. This shows that individual laboratory work strategy caused improvement in the level of practical skills acquired by all the students, whose individual scores tended towards the mean score.

### Research Question 2:

What are students' mean scores by gender in the acquisition of Chemistry practical skills?

**Table 2:** Mean scores and standard deviation of scores of students by gender in acquisition of Chemistry practical skills.

Gender	N	Pre-test		Post-test		Mean Gain	Mean Gain df
		Mean	SD	Mean	SD		
Male	47	90.94	27.16	166.15	22.73	75.21	1.01
Female	37	88.19	27.73	164.41	27.40	76.22	

Table 2 shows the analyzed data concerning research question 2. The male students' mean gain score is 75.21, showing that the treatment caused a large change in the level of Chemistry practical skills possessed by male students. Moreover, the SD of males in the pretest and posttest declined from 27.16 to 22.73, showing that the treatment improved the practical skills of majority of the students because their scores tended to increase towards the larger mean score. For the female students, the mean gain score after treatment is 76.22. This is apparently large mean gain score. But when the mean gain score of male students is compared with that of female students, the difference is only 1.01 in favour of females. This shows that the treatment gives female students very slight advantage in the acquisition of Chemistry practical skills.

**H<sub>01</sub>:** Students' mean scores in acquired Chemistry practical skills do not depend on the use of group work or individual work teaching strategy ( $p < 0.05$ ).

Results of the ANCOVA in Table 3 show that teaching strategies are significant factors in students' acquisition of Chemistry practical skills. Group work and individual work teaching strategies have differential effects on students' mean level of acquisition of Chemistry practical skills,  $F(1, 75) = 14.653$ ,  $p = .000$ . Null hypothesis ( $H_{01}$ ) of no significant difference is therefore rejected.

**Table 3:** Summary of (ANCOVA) analysis comparing students' mean scores in Chemistry practical skills when taught using individual laboratory work and group laboratory work teaching strategies

Source	Type III Sum of Squares	df	Mean Square	F	Sig. of F
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Corrected Model	22051.017 <sup>a</sup>	8	2756.377	7.179	.000
Intercept	192715.162	1	192715.162	501.918	.000
Pretest	147.781	1	147.781	.385	.537
Method	5626.138	1	5626.138	14.653	.000*
Gender	5.056	1	5.056	.013	.909
Method * Gender	1.690	1	1.690	.004	.947
Error	28796.793	75	383.957		
Total	2348320.000	84			
Corrected Total	50847.810	83			

\*Significant at 5% alpha level.

This is because the exact probability value (.000) is less than the level of significance set a priori at 0.05 alpha level. Therefore, it was concluded that there is a significant difference in students' mean scores in acquisition of Chemistry practical skills when taught Chemistry using individual laboratory work and when taught using group work strategies. Group work is definitely more effective than individual work because students in group work achieved far higher mean score (174.04) than their counterparts working as individuals (153.83) on the same Chemistry practical activities.

**HO<sub>2</sub>: There is no significant difference in the mean scores on acquisition of Chemistry practical skills by students due to gender.**

Result of the analysis on Table 3 was used to test hypothesis two. The Table shows that gender is not a significant factor on students' acquisition of Chemistry practical skills if group work and individual work teaching strategies are used,  $F(1, 75) = 0.013$ ,  $p = 0.909$ . This p-value is far greater than the 5% alpha level set a priori for HO<sub>2</sub>. Therefore, the null hypothesis of no significant difference between the mean scores of male and female students was accepted. The researchers, therefore, concluded that there is no significant difference in the mean scores of students due to gender in acquisition of Chemistry practical skills. Results of the study show that female students acquired mean score in Chemistry practical skills (mean = 164.41) that is a little lower than that of male students (mean = 166.15) when Chemistry practical activities are taught using group work and individual work strategies. Further analysis (Table 3) revealed that gender did not significantly influenced students' acquisition of practical skills in Chemistry.

**HO<sub>3</sub>: There is no significant interaction effect of gender and treatment on the mean scores of students in Chemistry practical skills, ( $p < 0.05$ ).**

From Table 3, it can be observed that treatment by gender interaction effect is not significant at 5% level of significant. The actual value of the level of significant is,  $F(1, 75) = 0.004$ ,  $P = 0.947$ . The 0.947 is far greater than 0.05 alpha level at which the hypothesis had been proposed a priori. This means that students benefit from the teaching strategies irrespective of gender. None of the two strategies used for Chemistry practical instruction favours one sex against the other. Therefore, individual laboratory teaching/learning strategy and group work teaching/learning strategy can effectively be used in Chemistry practical instruction without disadvantaging any student based on gender.

### Discussion of the Findings

The superiority of group work was probably due to mutual support which students give to one another by discussing and sharing ideas, and reflecting on the tasks to find the best way forward. Weaker students were perhaps the greatest beneficiaries of the mutual support obtainable among student in group work strategy. This explains why the mean score of group work students rose sharply from pretest to post test while their standard deviation of scores reduced drastically by 5.04 points. The student-group discussion and sharing of ideas engendered in group work strategy could not have happened in the classes where students worked as individuals on their own learning tasks. The superiority of group work over individual work in science practical activities has also been reported by some other researchers, (Njoku 2009). It was therefore concluded that group work teaching/learning strategy significantly enhanced students' acquisition of Chemistry practical skills when compared with individualized laboratory work teaching/learning strategy.

The findings of this study is in agreement with the results of the studies by Iyang & Ekpeyin, (2010); Raimi (2012); Agommuoh & Nzewi, (2003); Babajide, (2010). These studies found that gender has no significant influence on students' achievement in science irrespective teaching strategies applied. Although the findings of this study with respect to influence of gender is in agreement with the findings of the above cited researchers, they are in contrast with the findings of an earlier study which established that female students achieved significantly higher mean scores in Chemistry practical activities than male students if the students worked in sex groups in coeducational schools, (Njoku 1997). Therefore, the influence of gender on students' performance in science practical activities remains inconclusive. More factors than gender tend to operate during science practical activities in coeducational classrooms.

### Summary of Findings

Based on the results of this study, the following findings are observed:

- (1) The use of group work learning strategy in Chemistry practical work significantly enhanced students' acquisition of Chemistry practical skills more than individual laboratory work.
- (2) Gender has non-significant influence on students' acquisition of Chemistry practical skills. Male and female students had little or no differences in their means scores in Chemistry practical skills acquisition. Statistically the mean difference of 1.01 in favour of females is a chance occurrence, hence it is statistically not significant at 5% alpha level.
- (3) Gender by treatment interaction is not a significant factor in students' mean acquisition of Chemistry practical skills if group work and individual work are the teaching/learning strategies used in practical Chemistry at secondary school level. This is an indication that neither the male nor the female is placed at advantages due to the teaching strategy.

### Conclusion

School Chemistry practical work can be carried out more fruitfully using group work teaching/learning strategy more than individual work which used most of the time by the Chemistry teachers. Group practical work has proved to enhance students' acquisition of Chemistry practical skills more than individual work. Gender has no statistically significant influence on students' acquisition of Chemistry practical skills hence the two strategies are effective for both male and female students. The interaction of gender and teaching strategies is statistically not significant.

## Recommendations

Based on the findings and conclusion of this study, the following recommendations were proffered.

1. Chemistry teachers should adopt group work strategy in their Chemistry laboratory teaching/learning activities as it enhances the overall performance of students in Chemistry practical activities.

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