



Effects of Practical Chemistry Teaching Strategies on Acquisition of Practical Skills by Students' of Different Cognitive Styles in Secondary Schools in Kogi State.

Tsobaza M. K.

Department of Primary Education Studies, Kogi State College of Education, Ankpa.

Corresponding Author's E-mail: psmopah@gmail.com

Abstract

The study investigated the effect of cognitive styles on students' acquisition of practical skills in chemistry. The study adopted the non-equivalent group design. Two research questions and three null hypotheses guided the study. A sample 84 senior secondary 111 chemistry students from two intact classes in two secondary schools participated in the study. The instruments for data collection were Chemistry Practical Skills Rating Scale {CPSRS} and Group Embedded Figure Test {GEFT}. Data collected for study were analyzed using mean and standard deviation while Analysis of Covariance {ANCOVA} was used to test the hypotheses at 0.05 level of significance. The study revealed that field independent{FI} students significantly influenced students acquisition of practical skills compared to field dependent students{FD}. The study also revealed that there is significant influence of cognitive styles and gender on students' acquisition of practical skills in chemistry. Treatment by cognitive styles interaction effect was not significant at 5% alpha level. Based on these findings, it was recommended, among others that chemistry teachers should organize their lessons in such a way that students of different cognitive styles could benefit optimally.

Introduction

Chemistry can be taught and learned most effectively if Chemistry is supported by practical activities. Practical activities are the hall mark for Chemistry teaching at all levels of education (Adane & Adams, 2011). Students have a lot to benefit from practical work which may include increasing students' performance and abilities in Chemistry. One of the goals of Chemistry education is to develop students' learning skills in Chemistry. The goal of helping students in acquisition of practical skills may not have been achieved due to inappropriate teaching strategies, poor classroom practices which may result from inadequate knowledge of students' cognitive styles on the part of Chemistry teachers and educators'. Cognitive styles are the preferred ways individuals think to solve a given task. Chemistry is essentially a practical oriented subject which demands proper teaching and learning strategies for effective interpretation of existing phenomenon (Njelita, 2008). Students are rarely exposed to practical work; hence Ankpan (1999) observed that lack of practical activities by Chemistry students has resulted in poor communication and observational skills. The absence of these skills gave rise to students' poor performance in practical Chemistry in both internal and external examinations.

However, Achimugu (2013), Njoku (2009), Ali (1998) have stated that a major factor for effective learning to take place is the use of interesting

instructional approach that enhanced participation of students in the teaching and learning process. Ogbu (2012), Ajeyaleme and Owoyemi (2014) have suggested a shift from the conventional method of teaching Chemistry to some innovative instructional approaches to ensure improvements and performance of students in the subject.

The study used the individual and group work teaching/learning strategies. Individual laboratory strategy is when each student is given a set of equipment to carry out specific chemistry practical activities. Conversely, group work is a way of getting students to work together to solve problems or learn new information. Teachers of chemistry usually adopt the individual laboratory work or the grouping strategies. Their choice of a teaching strategy depends largely on the availability of equipments and materials for carrying out the laboratory activities. A strategy is defined as a method of carrying out a given task. By adopting the individual strategy, teachers of chemistry think that students would acquire the real scientific skills and experience when compared with grouping strategy which they often think it is adopted only when materials for learning are inadequate for students in the laboratory. Teachers of chemistry may not have taken into cognizance the influence of cognitive styles on practical chemistry teaching strategies. According to Okwo and Otuba (2007) students' cognitive style may hinder or facilitate the acquisition of practical



skills in chemistry. Pitcher (2012) defined cognitive style as a relatively stable strategies, preferences and attitude that determine an individual's typical modes of perceiving, and remembering learned information or problem solving. Cognitive style can also be defined as the unique way individual perceives information that becomes valid, meaningful and useful to them. Studies have expressed the disparity in the performance of students based on cognitive styles and gender (Iyang and Epeyong, 2010). Ahiakwo (2012) found no significant difference in the performance of both field-independent and field-dependent problem solving ability in chemistry. By contrast, Okoye (2011) found that field-independent students did better than field-dependent students in academic achievement in biology. Alegria (2012) found that field-dependent people had a poorer academic achievement than field-independent people. The influence of cognitive styles and students' performance is still a controversial one among science education researchers. Wagbara (2015) found that cognitive style has significant influence on students mean score in chemistry. Gender does not have significant influence on mean score of students of different cognitive styles in chemistry Wagbara (2015). Duru (2012) revealed that there was no significant difference between the performance of male and female students taught with competency – based instructional method. In contrast, Agba (2009) in his study revealed that there was significant difference in the mean performance of male and female students' creative thinking test in favour of the females. The influence of cognitive styles and gender on students learning outcomes in practical chemistry is not clear. In the present study it is not clear how cognitive styles and gender can affect students learning outcomes in practical chemistry. It is therefore necessary to investigate the joint influence of cognitive styles and gender on students' acquisition of practical skills in chemistry.

A student is either a field-independent (FI) or Field-Dependent (FD) cognitive style learner. A field-independent style learner is described as being analytic, competitive, individualistic, task-oriented, non-verbal and passive who prefers individual work and have poor social skills. A field-dependent cognitive style learner is described as a global person, sensitive to social interactions and criticisms, which prefer external information and group work. (Cano, 2006, Danili & Reid, 2006; Garton, Ball, & Dyer, 2002; Hederick, 2004).

Cognitive styles influence the way an individual learn and acquire information. If chemistry teachers understand their students; it will help them adopt more effective teaching strategy that will suit the needs of students which will invariably improve students' acquisition of skills and knowledge in chemistry. Students will understand and recall faster when the instructional strategy is exactly matched with their cognitive styles. Conversely, those whose cognitive styles do not match with instructional strategy learn slowly with difficulties. It is therefore important for teachers of chemistry to understand their students' cognitive styles so that the instruction for learning would be matched according to their cognitive styles. This study therefore sought to compare the effects of cognitive styles (field-independent & field dependent) on students' acquisition of practical skills at secondary school level.

Objectives of the study:

1. Ascertain the influence of cognitive styles on students' acquisition of practical skills.
2. Ascertain the influence of gender and cognitive styles on acquisition of practical skills in Chemistry
3. Ascertain the interaction effect of teaching strategies and cognitive styles on acquisition of practical chemistry skills

Research Questions

The following two research questions guided the study:

1. What is the mean scores of different cognitive styles on students' acquisition of practical skills?
2. What is the mean scores of different cognitive styles on students' acquisition of practical skills based on gender?

Hypotheses

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

- Ho₁: There is no significant difference in the mean scores in acquisition of practical skills of the students due to their cognitive styles ($p < 0.005$).
- Ho₂: There is no significant difference in the mean scores of cognitive styles and gender on acquisition of practical skills in Chemistry ($p < 0.005$).

H₀₃: There is no significant interaction effect of teaching strategies and cognitive styles on students' acquisition of practical chemistry skills ($p < 0.005$).

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 of the study comprised of senior secondary schools 3 (SS 3) chemistry students from 68 secondary schools from Anka Education Zone. (Ministry of Education, Area Education, Anka)

A sample of 84 SS 111 Chemistry students from Anka Education Zone was composed as follows: Through simple random sampling (balloting) one Zone out of the three education zones in Kogi east senatorial district was drawn. The education zone that was drawn is Anka. Anka education zone is composed of three local government areas. They are: Anka, Olamaboro and Omalla local government areas. The second round of simple random sampling by balloting was used to draw two local government areas. The local government areas drawn were Anka and Ollamaboro. The purposive sampling technique was used to select two intact classes from two co-educational schools offering chemistry one from each local government areas. There were 27 male students and 21 females in the first intact class while the second intact class was composed 20 males and 16 females. All together 84 students participated in the study. The researcher developed lesson plans on chemistry practical activities-quantitative analysis. The lesson plans were face validated by two experienced teachers of chemistry. These lesson plans were used for teaching all the lessons needed in the study. For data collection, the researcher adopted two instruments; these are Group Embedded Figure Test (GEFT), the chemistry practical skills rating scale (CPSRS).

Group Embedded Figure Test (GEFT) is an 18-item instrument was adopted for the study. The instrument was developed by Otman, Raskin and Witkin (1971) in America. GEFT is a standard instrument used to categorize learners into field-dependent and field-independent cognitive style groups. GEFT has gained wide acceptance. In Nigeria, GEFT has been used by Achor (2001), Iorchugh (2006), Okoye (2011) and Wagbara (2015) and were not subjected to validation.



Otman, Raskin & Witkin found the reliability coefficient of GEFT to be 0.82. GEFT is preferred for use in this study because;

- i) It is universal instrument to ascertain cognitive style (Mind, 2013).
- ii) It does not consume time in providing solutions to items.
- iii) The psychometric properties of GEFT have been investigated in different settings (Mind, 2013). The field dependent and the field independent cognitive style involve, students' ability to identify relevant figures containing twenty-five geometric designs.

The complex designs are arranged in three sections. The first section comprises seven designs that were used for the practice before the actual test. The second and third sections contain new complex figures each. 45 minutes was allowed for the actual test. For each item a score of "1" or "0" is awarded if the simple form is correctly or incorrectly outlined respectively. A score of 0-8 indicated field-dependent; while a score of 9-18 represented a field-independent cognitive style learner. The result after GEFT was administered were as follows; total number of Field Dependent chemistry students was 41 while Field Independent chemistry students were 43. The number of field Dependent males was 20, while Field Dependent females were 21. The Field Independent males were 27 and their female counterpart were 16 making a total of 84 research subjects. Chemistry Practical Skill Rating Scale (CPSRS) is a practical test instrument that was adopted for this study. 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 item of the scale are called behavioral categories which are unevenly distributed among the eight subscales called skill categories. The skill categories include: manipulative skill and conduct of experiment, controlling extraneous variables, measurement skill, work habit, safety skill, inferring and interpretation of observation or data, mathematical computation, and skills in observation, recording of data and communication skills. During its development the CPSRS was pilot-tested and Kendall's Coefficient of Concordance (W) was used to determine the inter-rater reliability of the CPSRS. (W) Was used in order to control the error that arises from raters and to assess the extent of agreement of scores to ensure that



the scoring patterns of all the scorers are the same. The value of (W) obtained was 0.55 shows there is positive relationship among the sets of ranks. 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 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 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, the first 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 researcher. The duty of the teacher was to assist the researcher carry out the teaching using the prepared lesson plans, while the researcher supervised to ensure that procedures were followed at all times. The topics covered were on quantitative analysis.

The second group on the other hand was taught the same topics on quantitative analysis using grouping 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 the record the level of skills exhibited by the research subjects during the practical chemistry work. The duration of the practical chemistry test was deliberately extended to ensure that the research subjects completed all the items of the test, and 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

Table 1: Mean rating scores and standard deviation of students in acquisition of practical skills of different cognitive styles.

Cognitive styles	Pre-test			Post-test		Mean gain scores	Mean Gain Difference
	N	Mean	SD	Mean	SD		
Field Dependent (FD)	41	84.95	25.54	151.49	25.55	66.54	17.81
Field Independent (FI)	43	94.28	28.40	178.63	14.86	84.38	

Result in table 1 revealed that at pre-test, field dependent (FD) students had mean acquisition of practical skills score of 84.95 with a standard deviation of 25.54 while field independent students had mean acquisition of practical skills score of 94.28 with standard deviation of 28.40. At the post test, FD students had mean acquisition of practical skills score of 151.49 and standard deviation of 25.55 while FI students had mean acquisition of practical skills score of 178.63 with standard deviation of 14.86. The mean gain score of FD students was 66.54 while the mean gain score of FI students was 84.35. The result therefore, show that FI students had a higher mean acquisition of practical skills score compared to FD students. This can be seen from a mean gain score difference of 17.81 in favour of FI students.

Research Question 2:

Table 2: Mean and standard deviation of cognitive styles and gender on acquisition of practical skills in Chemistry.

Cognitive styles	Gender	N	Mean	SD
Field Dependent	Male	20	150.50	24.56
	Female	21	152.43	27.04
Field Independent	Male	27	177.74	12.05
	Female	16	180.13	19.04

Result in Table 2 revealed that male student who fall under field dependent had a mean acquisition of practical skill of 150.50 and standard deviation of



24.56 while their counterparts under field-independent had a mean acquisition of practical skill score of 177.74 with standard deviation of 12.05. On the other hand, female students under field-dependent had a mean acquisition of practical skill score of 152.43 and a standard deviation of 27.04. While their female counterparts under field-independent had a mean acquisition of practical skill score of 180.13 with standard deviation of 19.04.

The mean score of field dependent male in table two is 150.50 while the mean score of field dependent females is 152.43 which show an observed mean score difference of 1.93. These on the mean score of males and female, in Chemistry practical skills as shown in table two indicated that the field dependent females acquired chemistry practical skills better than the field-dependent males. However, the mean score difference was not significant.

Field-independent males had mean score of 177.74 while the field-independent females had mean score of 180.13. This means that the field-independent females did better than the field-independent males

and the mean difference is 2.39. The mean score difference was not significant. further analysis to show whether gender have significant influence on students mean score in practical chemistry would be determined by testing the hypothesis of this study.

Results of the analysis in table 3 was used to test hypothesis one. The table shows that cognitive style is a significant factor on students' acquisition of practical skills in chemistry; $F(1, 75) = 31.542$, $P = .000$. Therefore, the null hypothesis of no significant difference was rejected because the exact probability level of .000 is less than level of significance set at 0.05. The researcher therefore, concludes that there is a significant difference in the mean scores on acquisition of practical skills of students due to cognitive styles.

Table 3: Analysis of covariance (ANCOVA) of acquisition of practical skills of students taught chemistry using individual laboratory work and those taught using group work

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	22051.017 ^a	8	2756.377	7.179	.000
Intercept	192715.162	1	192715.162	501.918	.000
Pretest Ach	147.781	1	147.781	.385	.537
Method	5626.138	1	5626.138	14.653	.000
Gender	5.056	1	5.056	.013	.909
Cognitive Styles	12110.625	1	12110.625	31.542	.000
Method * Gender	1.690	1	1.690	.004	.947
Method * Cognitive Styles	70.236	1	70.236	.183	.670
Gender * Cognitive Styles	.000	1	.000	.000	.999
Method * Gender * Cognitive Styles	1008.790	1	1008.790	2.627	.109
Error	28796.793	75	383.957		
Total	2348320.000	84			
Corrected Total	50847.810	83			

The result of the analysis in Table 3 was also used to test hypothesis two. The result in the table shows that the probability value of 0.999 associated with gender cognitive styles is greater than 0.05 level of significance; ($F(1, 75) = 0.000$, $P = 0.999$), thus, the null hypothesis of no significant effect of gender and cognitive styles on students' acquisition of practical chemistry skills is accepted. The researcher therefore, concludes that the influence of gender and cognitive

styles on students' acquisition of practical skills is not significant.

From table 3 it can be observed that treatment by cognitive styles interaction effect is not significant at 5% level of significant. The actual value of the level of significant is, $F(1, 75) = 0.183$, $P = 0.670$. Thus, the null hypothesis is accepted since the probability value of 0.670 is greater than the level of significance set at 0.05. Therefore, the researcher concludes that the interaction effect of teaching strategies and



cognitive styles on students' acquisition of practical chemistry skills is not significant.

Discussion

In table 1, it was observed that at pretest and post-test, the mean acquisitions of practical skill scores were higher in field-independent students than in field-dependent students. This shows that field independent students acquired Chemistry practical skills better than the field dependent students. The result showed that cognitive styles have significant influence of students' mean scores in Chemistry practical skills. The result of this study is in agreement with the findings of the studies by Okoye (2014); Alegria (2012); (Cano, 2006, Danili & Reid, 2006, Garton & Ball & Dyer, 2002, Bahar & Hansel, 2010, Achor 2001). As they concluded that field-dependence, places student at risk of poor school outcomes, whereas field independence favours students success. Gender does not have significant influence on the mean scores of students' of different cognitive styles. The result of this study is in agreement with that of (Wagbara, 2015, Neboh 2009, Nwosu, 2001; Duru, 2012;) as the findings of their study showed that gender does not significantly influenced students' acquisition of chemistry practical skills.

Conclusion

These results indicate that students' practical skills are influenced by their cognitive styles. The field independent learners acquire practical skills better than the field dependent learners in chemistry. There is no significant difference of gender and cognitive styles on students' acquisition of practical skills in chemistry as indicated in the study. Interaction effect of teaching strategies and cognitive styles on students' acquisition of practical chemistry skills is not significant.

Recommendations

1. Chemistry teachers should organize their lesson in such a way that students of different cognitive styles could benefit optimally. For instance, chemistry teachers need to discover the cognitive styles of their students group them accordingly and motivate them to study practical chemistry. Field dependent students need greater motivation and encouragement to improve their performance in practical chemistry activities.

2. Teachers of chemistry should guide and give students of different gender equal activities in chemistry laboratories and classes so that students of the same cognitive style and different gender could have maximum and equal interest in chemistry.
3. The number of periods per week should be increased for chemistry classes as to give room for enough laboratory activities, so that field dependent learners that have been identified by the teachers could be taught for a long time.

References

- Achimugu, L. (2013). Instructional modes of teaching and learning Chemistry in senior secondary schools under MDGS, NEEDS and Education's Reform Agenda STAN 54th Annual Conference (248-254).
- Achor, E.E. (2001). Effect of guided discovery student's cognitive styles and cognitive demands of senior secondary school physics curriculum. (*Unpublished Ph.D. Thesis*), University of Nigeria, Nsukka.
- Achor, E.E. (2010). Effect of guided discovery students cognitive style and cognitive demands of senior secondary school physics curriculum. (*Unpublished Ph.D Thesis*), University of Nigeria, Nsukka.
- Adane, L. & Adams, A., (2011). Relevance and safety of chemistry laboratory experiments from students' perspective: a case study at Jimma University, South Western Ethiopia. *Educational Research*, 2(13) 1749-1758
- Agba, I.I. (2009). Effect of cognitive research trust training programme on creative thinking among secondary school students. *Unpublished students Ph.D Thesis* of the University of Nigeria Nsukka.
- Ahiakwo, M.JH. (2012). Cognitive styles and students problem-solving competences in Chemistry *Journal of Science Teacher Association of Nigerian*. 26(1), 19-22.
- Ajeyami, D. & Owoyemi, T.E. (2014). Strategies for teaching carbon and its compounds,



Hydrocarbon and crude oil at junior secondary school STAN Chemistry panel series 10(1-9).

Akpan, E.U.U. (1999). Towards Evaluation Laboratory Practices: A Survey Plateau State Secondary Schools. In Evaluating Science Technology and Mathematics Education, 40th Annual Conference Proceeding of STAN, pp.117-122.

Ali, A.A. (1998). *Strategies issues and trends in science education in Africa*. Onitsha: Cape publisher, International Limited.

Bahar, M. & Hamsel, M. (2010). the relationship between some psychological factors and their effects on the performance of grid questions and word association test. *Educational Psychology*. 20, 349-361.

Cano, Y. (2006). Effect of field dependent-Independent cognitive styles and cueing on students recall and comprehension, (Unpublished doctoral dissertation). Virgini A Polytechnic Institute, Blacksburg, V.A.

Danili, E., & Reid, N. (2006). Cognitive factors that can potentially affect pupils test performance. *Chemistry Education Research and practice*, 7, 64-83.

Duru, D.D. (2012). Competency based instructional method and practical skills development in wood work technology of Federal College of Education (Technical Omoku) *Ph.D Thesis Unpublished* of the department of CEST University of Port Harcourt.

Garton, B.L., Ball, A.L. & Dyer, J.E. (2002). The academic performance and retention of college of agriculture students. *Journal of Agricultural Education*, 29, 462-482.

Hederich, C. (2004). Estilo cognitivo en la dimension de dependencia-independencia de campo. Influencias culturales implicaciones para la education. (Unpublished Doctoral dissertation). Unversidad Autonoma de Barcelona, Spain.

Iorchugh, A.S. (2006). Influence of cognitive styles, cognitive level and gender on students' achievement in physics. (Unpublished M.Ed. Project), University of Nigeria, Nsukka.

Iyang, N.E. U & Ekpeyong, H.E. (2010). Influence of ability and gender grouping on Senior Secondary School Chemistry Students' Achievement on the concept of Redox reactions. *Journal of Science Teachers Association of Nigeria*, 35(1) 36-42.

Mindgarden (2013). Group embedded figures test sampler Set. Manual and Sample. Figures and Scoring. www.mindgarden.com.

Nebob, O.I. (2009). Effects of learning activity package (LAP) on students' achievement and retention in Senior Secondary School Biology. *Unpublished student Ph.D Thesis* of the University of Nigeria, Nsukka

Njelita, C.B. (2008). Enhancing science process skills acquisition in volumetric analysis using cooperative learning strategy. *Paper Presented at the Workshop organized by Science Teachers Association*, 34, (1 & 2), 83-89.

Njoku, Z.C. (2009). Enhancing the relevance of Chemistry curriculum delivery using science technology society (S-T-S) approach. Holbrook, J. & Eninyeju, P.C. (Eds.), *Proceeding of African Regional Conference of International Council of Association for Science Education*. (pp. 48-54). Ibadan: Oluseyi Press Ltd.

Nwosu, A.A & Okeke, E.A.C. (1995). The Effects of Teachers Sensitization of Students' acquisition of Science process skills. *Journal of the Science Teachers' Association of Nigeria*. 30(1&2) 39-45.

Ogbu, C.C. (2013). Effects of contexed based teaching strategy on senior secondary students' achievement in physical chemistry. *53rd Annual Conference of STAN* (265-271).

Okoye, P.O. (2011). Influence of Classroom Interaction Patterns and Students Cognitive



Styles on Achievement Biology in Senior Secondary Schools in Anambra State. (*Unpublished Ph.D Thesis*), University of Nigeria, Nsukka.

Okwo, F.A. & Otubar, S. (2007). Influence of gender and cognitive styles on students' achievement in physics essay test. *Journal of Science Teacher Association of Nigeria*, 42(1 & 2).

Pitcher, R.T. (2012). A review of the field-dependent field independent Approach. *Journal of Vacations Education and Training*. 54(1), 177-182).

Wagbara, S.O. (2015). Influence of cognitive styles on secondary school students' interest and acquisition of practical skills in Chemistry. *An Unpublished University of Nigeria Ph.D Thesis*.

Wagbara, S.O. (2015). Influence of cognitive styles on secondary school students' interest and acquisition of practical skills in Chemistry. *An Unpublished Ph.D Thesis*, University of Nigeria, Nsukka.