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# **Effects of Cognitive Styles and Collaborative Instructional Strategy on Academic Achievement of Senior Secondary Chemistry Students in Benue State, Nigeria**

Prof. J. O. Eriba <sup>1</sup>, John Aondohemba GARBA <sup>2</sup>, Prof. M. J. Adejoh <sup>3</sup>,  
and Dr. O. K. Okwara <sup>4</sup>

<sup>1</sup> Department of Science and Mathematics Education, Benue State University, Makurdi, Nigeria

<sup>2,3,4</sup> Department of Science Education, Joseph Sarwuan Tarka University, Makurdi, Nigeria

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## **Abstract**

This study was on the effect of cognitive styles and collaborative instructional strategy on achievement of senior secondary chemistry students in Benue State, Nigeria. Two research questions guided the study and two hypotheses were formulated and tested. This study adopted the quasi-experimental research design and was conducted in Benue State. The population of this study was 28903 senior secondary II students from the 292 public senior secondary schools in Benue State which offer Chemistry. A sample of 154 senior secondary II students made up of 84 male and 70 female students from 6 secondary schools in Benue State was used. Two instruments were used for the collection of data. The instruments were Group Embedded Figure Test (GEFT) and Chemistry Achievement Test (CAT). The content and face validity of the instruments were carried out by three experts. The Split-half method was used to analyze the scores for reliability

coefficient which was found to be 0.71 for CAT and 0.88 for the GEFT. The instruments were administered to the respondents with the help of six research assistants. The GEFT instrument was administered first to the students in order to classify the students into their various cognitive styles. CAT was administered first as pre-test and then as post-test after teaching for eight weeks. Mean ( $\bar{x}$ ) and Standard Deviation (SD) were employed to answer the research questions while Analysis of Covariance (ANCOVA) to test the hypotheses formulated at 0.05 level of significance. The findings revealed that there is a significant difference between the mean achievement scores of students taught chemistry using collaborative instructional strategy and those taught using conventional method ( $F(1,151) = 51.67$ ;  $p = 0.00 < 0.05$ ). The findings also revealed that there was a significant difference between the mean achievement scores of chemistry students with field dependent and field independent cognitive styles when collaborative instructional strategy was used ( $F(1,63.79) = 5.45$ ;  $p = 0.02 < 0.05$ ). It was concluded in this study that the use of collaborative instructional strategy enhanced students' achievement in chemistry more than the conventional method and that the use of collaborative instructional strategy also favoured students with field-independent cognitive styles more than the field-dependent cognitive styles. It was recommended among others that Chemistry teachers should use collaborative instructional strategy which provides students opportunity to interact with their peers and enhance their achievement, Chemistry teachers should use collaborative instructional strategy which favoured both field-dependent and field-independent cognitive styles

**Keywords:** Chemistry Education, Cognitive Styles, Collaborative Instructional Strategy, Academic Achievement, Senior Secondary School

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## Introduction

Science and technology education is the bedrock of human civilization and development. Many of the developed nations were able to achieve their status of development through science and technology. At the secondary school level, science education is most commonly broken down into three fields of Biology, Chemistry and Physics. The fields of chemistry hold a paramount place in the modern world. Chemistry is a branch of science that deals with the structure, composition, properties and reactive characteristics of matter especially at the atomic and molecular levels. Applications of chemical science have contributed significantly to the advancement of human civilization. Chemistry synthesizes crop-enhancing agricultural chemicals to ensure a constant and viable food supply. Chemistry plays a significant role in the eradication of deadly diseases by developing life-saving pharmaceuticals and chemical pesticides. Knowledge of chemistry is very essential in power generation such as nuclear power and petrochemicals.

A credit in chemistry is a prerequisite for gaining university admission in courses such as medicine, pharmacy, engineering and nursing among others. Summarily, chemistry is a very crucial aspect of science, education and life as a whole. Therefore, every nation must give high level of priority to the subject and its study. Despite much effort made to ensure that students achievement in chemistry is improve, reports from the WAEC Chief Examiners (May/June, 2014, 2015, 2016 & 2017) show a trend of low achievement in chemistry. Madu and Ezeamagu (2013) defined achievement as the quality and quantity of a student's work feat. Akem (2007) sees achievement as success or result gained by students after being exposed to a learning program. Achievement is a yardstick which determines the success or failure of teaching-learning process. Research report such as Okebukola (2006) found that students' achievement in chemistry at the senior secondary school certificate examination is low. While this has been attributed to shallow knowledge of the

subject, Atamonokhai (2017) in a research on the effect of some factors on students' achievement in chemistry stated that in spite of the attempts made by researchers to improve on the teaching and learning of Chemistry, the achievement of students in the subject remains low in Nigeria.

Broadly speaking, many factors have been shown to have significant impact on students' achievement in Chemistry. One of the categories of factors is the student or learner factor (Nbina, 2012). The learner, himself is a central factor in determining whether meaningful learning will take place or not. This may include his background, motivation, age, sex or gender, personality, cognitive style and so on (Ogunleye, 2011; Bassey, Umoren & Udida, 2013). In a similar view Iji, Ochu, Adikwu and Atamonokhai (2017) listed factors responsible for this low achievement in chemistry to include use of inappropriate teaching methods, lack of instructional materials, inadequate number of qualified teachers and inability to identify the cognitive styles of learners. Bassey, Umoren and Udida (2013) also argued that students' achievement may be low when the teaching method is inappropriate to students' cognitive style. Knowledge of students' cognitive styles could be used to predict what kind of instructional strategies or methods would be most effective for a given individual and learning task. However, the situation in most classrooms in Nigeria is that teachers have little or no knowledge of students' cognitive style.

Cognitive style as defined by Armstrong and Peterson (2012) is the individual differences in peoples preferred way of processing (perceiving, organizing and analyzing) information using cognitive brain-based mechanisms and structures. Cognitive styles are psychological constructs which describe individuals' mode of information perception, organization and presentation (Arisi, 2011). Cognitive styles are thought to be relatively stable strategies, preferences and attitudes which determines an individual's typical modes of perceiving, remembering and problem-solving (Abubakar, 2016). Cognitive styles describe a person's typical mode of thinking, remembering or problem solving. Cognitive style is usually described as a personality dimension which influences attitudes, values, and social interaction (Chapelle & Green, 2012).

Cognitive researchers have identified a number of cognitive styles. For instance Witkin (1962) identified two cognitive styles to include 'field independence and field dependence', Pavio (1971) mentioned two cognitive styles to include 'verbaliser and visualiser' while Kagan (1965) identified two cognitive styles as 'Impulsivity and reflexivity'. Field independence and field dependence are probably the most well-known styles. In cognitive style, the field dependent learners are those learners who are most affected by their environment. They are inclined to overall field learning and tend to get the whole idea whereas the field independent learners conduct an analytical procedure and are more likely to break a model into different sections and details and tend to depend on their inner knowledge and analyze problems all by themselves without reference to the frame or the environment (Bakar & Ali, 2013). At a perceptual level, field independent personalities are able to distinguish figures as discrete from their backgrounds compared to field dependent individuals who experience events in an undifferentiated way (Cao, 2016).

In addition, field dependent individuals have a greater social orientation relative to field independent personalities. Studies have identified a number of connections between this cognitive style and learning (Abubakar, 2016). For example, field independent individuals are likely to learn more effectively under conditions of intrinsic motivation (e.g., self-study) and are influenced less by social reinforcement. Study by Grossmann (2011) revealed that field dependent learners

perceive the world globally, find it difficult to solve problems, tended to favour spectator approach to learning and adopt the organization of information to be learnt. Field dependent learners are portrayed as holistic, uncertain and dependent upon others while field independent learners are seen as analytic, self-reliant and confident (Chapelle & Green, 2012).

From the foregoing, if cognitive styles of learners are taken into consideration in the delivery of lessons, it seems meaningful learning could be enhanced. Al-Saai and Dwyer (2013) stated clearly that if the educational subjects and materials conform to students' cognitive styles, it will lead to a better performance. Cao (2016) noted that field dependent people were better at learning materials with high human contents than the field independent ones. A study conducted by Chen, (2018) yielded the result that field dependent individuals were better at recalling social information such as conversation and relationships. Garrison, Anderson and Arher (2013) reported that field dependent individuals were more strongly influenced by the immediate social context and more inclined to attend to and learn about social aspects of their environments and that field dependent individuals show greater incidental learning for social materials than do field independent individuals. Grossmann (2011) affirmed that field dependent learners are more socially oriented than field independent ones. They pay more attention to social cues, they like to be with others and they seek learning and vocational experiences that put them in contact with people. The field independent learners on the other hand are good in task that requires critical thinking, analytical solutions and preferred working individually on their task.

As explained above, field-dependent and field-independent learners' process information differently and may require different teaching strategies and materials. Knowledge of students' cognitive styles could be used to predict what kind of instructional strategies or methods that would be most effective for a given individual and learning task. However, the situation in most classrooms in Nigeria is that teachers have little or no knowledge of students' cognitive style. Moreover, in a single class there are both field-dependent and field-independent learners, the teacher therefore has to select collaborative teaching strategies and materials that could be suitable for both field-dependent and field-independent learners.

Constructivism instructional strategies seem to provide suitable learning opportunities for both the field-dependent and field-independent; hence researchers such as Al-kaabi (2016) advocate the use of constructivism instructional strategies for teaching science to students of different cognitive and social background.

Constructivist learning holds that people construct their own understanding and knowledge of the world through experiences with people and materials and reflecting on those experiences (Vygotsky, 1924). When a learner encounters something new, he has to reconcile it with his previous ideas and experiences, maybe by changing what he believes, or discarding the new information as irrelevant. In any case, the learner is an active creator of his own knowledge. To do this, he must ask questions, explore, and assess what he knows. This theoretical framework holds that learning always builds upon knowledge that a student already has.

Based on constructivist learning theory, constructivist instructional strategies such as discovery, inquiry, collaborative among others, have been developed and are being used in teaching

science. Most of these strategies rely on some forms of guided discovery where the teacher avoids most direct instruction and attempts to lead the students through questions and activities to discover, discuss, reflect and verbalize the new knowledge (Arisi, 2011). One of the constructivists teaching strategies that could have the potentials of accommodating both field-dependent and field-independent learners is the collaborative instructional strategy. This is because collaborative instructional strategies a teaching and learning strategy that involves small groups of students working together to solve a problem, complete a task, or create a product. Collaborative instructional strategy is based on the idea that learning is a naturally social act in which the participants talk among themselves (Gerlach, 2014). Collaborative instructional strategy is a teaching strategy that enables students to interact freely with learning materials while collaborating with each other to create meaning (Johnson, 2010). It is through the talk that learning occurs.

Jenkins and O'Connor (2011) asserted that collaborative instructional strategy is one of the strategies suitable for teaching students with different cognitive styles in the classroom. The collaborative instructional strategy is associated with increased mental activity in relational and emotional memory connections and long-term memorization. In collaborative learning students made contributions among a group of peers and achieve success and all participating students increased their understanding of skills and ideas by explaining them to their peers.

The conventional method is one of the earliest method of teaching science (Nwagbo & Chikelu, 2011). In its true form, the conventional method is characterized mostly by a one-way flow of information from the teacher, who is active throughout the lesson, writing on the chalk board and talking to the students who are passive listeners. For this reason, the chalk and talk method is said to be didactic in nature because most of the talking is carried out by the teacher while the students remain passive listeners, taking down notes and asking few questions (Muhammad, 2017). The conventional method is widely used by secondary school Chemistry teachers. This is affirmed by Olagbaju (2019) who stated that an overwhelming majority of science teachers (chemistry teachers inclusive) still prefer the use of chalk and talk method in teaching. The wide use of the conventional method corresponds with the wide failure in Chemistry among secondary school students. It could be that, the conventional method is not effective in chemistry teaching hence the low achievement in Chemistry be witness. Also Samba and Eriba (2012) have put the blame of poor achievement in Chemistry on the classroom teacher's professional training which may have affected their methods of teaching. However, the effectiveness or otherwise of the conventional method in Chemistry teaching can only be proved in an empirical study such as the present study.

Many researchers such as Aliand Hasan (2009); Bruno (2015); Naurzalina, Karimova, Sarkulov, Tolegenova and Zholamanova, (2015); Idika, (2017) have used survey research designs in conducting researches on students' cognitive styles. These researches have not completely answered the question of effect of teaching strategies on achievement of students with field dependent and field independent cognitive styles. Therefore there is need to give field dependent and field independent learners exactly the same opportunity and challenges in collaborative instructional strategy in this study to enable the researcher ascertain if it could facilitate their academic achievement in Chemistry.

## Statement of the Problem

Studies on achievement patterns in Chemistry clearly show that there is a relatively steady decline in students' overall achievement and interest in Chemistry. This problem continues to generate public concern and outcry in Nigeria. Previous researchers have blamed this persistent low achievement on many factors including the use of ineffective methods for teaching Chemistry in secondary schools. The failure of teachers to identify students' cognitive styles and adopt suitable teaching strategies might have been the cause of low achievement and interest in chemistry. Finding such strategies for teaching Chemistry at the senior secondary level is imperative because of the central position of chemistry in Science education. The low achievement in chemistry imply that only few candidates will apply to study Chemistry and Chemistry related courses in higher institutions which could lead to shortage of man power in the field of chemistry in Nigeria. But if students can achieve higher in chemistry at the senior secondary level, they will likely pursue science courses at the tertiary level.

The poor achievement in chemistry could be because many teachers are not aware of students' cognitive styles. Hence, such teachers do not use appropriate instructional strategies that are suitable with the students' cognitive styles. More so trying collaborative instructional strategy against students' cognitive styles has not been a common study and how much difference collaborative instructional method will make to field-dependent and field-independent learners in chemistry class is yet to be determined through experimental study in Benue State. Thus, the major interest of this study is to find out the effects of cognitive styles and collaborative instructional strategy on academic achievement of senior secondary school Chemistry students in Benue State.

## Objectives of the Study

The Objectives of this study was to investigate the effects of cognitive styles and collaborative instructional strategy on academic achievement of senior secondary students in Chemistry in Benue State. Specific objectives of the study were to:

- i. determine the difference between the mean achievement scores of students taught Chemistry using collaborative instructional strategy and those taught using conventional method.
- ii. determine the difference between the mean achievement scores of Chemistry students with field dependent and field independent cognitive styles when collaborative instructional strategy is used.

## Research Questions

The study was guided by the following research questions:

- i. What is the difference between the mean achievement scores of students taught Chemistry using collaborative instructional strategy and those taught using conventional method?
- ii. What is the difference between the mean achievement scores of Chemistry students with field-dependent and field-independent cognitive styles when collaborative instructional strategy is used?

## Statement of Hypotheses

The following hypotheses were tested at 0.05 level of significance.

- i. There is no significant difference between the mean achievement scores of students taught Chemistry using collaborative instructional strategy and those taught using conventional method.
- ii. There is no significant difference between the mean achievement scores of Chemistry students with field-dependent and field-independent cognitive styles when collaborative instructional strategy is used.

## Research Methods

This study adopted the quasi-experimental research design. This study was conducted in Benue State. The population of this study was 28, 903 senior secondary II students from the 292 public senior secondary schools in Benue state which offer Chemistry. A sample of 342 senior secondary II students from six secondary schools in Benue State was used. Two instruments were used for the collection of data. The instruments are: Group Embedded Figure Test (GEFT) and Chemistry Achievement Test (CAT). The content and face validity of the instruments was carried out by three experts. The Kuder Richardson Formula (K-R20) was used to analyze the scores for reliability coefficient of CAT and GEFT. The reliability coefficient was found to be 0.71 for CAT and 0.88 for the GEFT.

The instruments were administered to the respondents with the help of twelve research assistants. The GEFT instrument was administered first to the students in order to classify the students into their various cognitive styles. CAT was administered first as pre-test and then as post-test after teaching for eight weeks. The scripts from each student were collected, marked, scored and used for analysis. Mean ( $\bar{x}$ ) and Standard Deviation (SD) were employed to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the hypotheses formulated at 0.05 level of significance.

## Results

The results of the data analyses and interpretation are presented according to the research questions and hypotheses formulated for the study.

### Research Question One

What is the difference between the mean achievement scores of students taught chemistry using collaborative instructional strategy and those taught using conventional method?

**Table 1: Mean and Standard Deviation Scores of Students Taught Chemistry Using Collaborative Instructional Strategy and Those Taught Using Conventional Method**

Group	N	Pre-test		Post-test		Mean gain
		Mean	SD	mean	SD	
Collaborative	84	34.29	11.03	54.25	15.03	19.96
Conventional	70	33.84	11.34	35.80	15.34	1.96
Mean Difference		0.45		18.45		18.00

Result in Table 1 reveals that students in the collaborative group have a mean achievement score of 34.29 in the pre-test and 54.25 in the post test with standard deviation of 11.03 in the pretest and 15.03 in the post test while those in the conventional group have a mean achievement score of 33.84 in the pretest and 35.80 in the post test with standard deviation of 11.34 in pretest and 15.34 in the post test. The collaborative groups have a mean gain of 19.96 while the conventional groups have a mean gain of 1.96. There was a mean difference of 18.45 in favour of the collaborative group. Therefore, the difference between the mean achievement scores of students taught chemistry using collaborative instructional strategy and those taught using conventional method is 18.45.

### Hypothesis One

There is no significant difference between the mean achievement scores of students taught chemistry using collaborative instructional strategy and those taught using conventional method.

The test result of this hypothesis one is presented in Table 2.

**Table 2: ANCOVA Result of Students Achievement Score when Taught Chemistry Using Collaborative Instructional Strategy and Those Taught Using the Conventional Method**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	26633.15	2	13316.58	94.06	.000
Intercept	27202.78	1	27202.78	192.13	.000
Achprt	13635.96	1	13635.96	96.31	.000
Gup	7316.14	1	7316.14	51.67	.000
Error	21378.99	151	141.58		
Total	371947.00	154			
Corrected Total	48012.136	153			

a. R Squared = .555 (adjusted R Square = .549)

Table 2 reveals that  $F(1,151)=51.67$  with p-value of 0.00 which is less than 0.05 level of significant set for this study. The hypothesis is therefore rejected. This implies that there is a significant difference between the mean achievement scores of students taught chemistry using collaborative instructional strategy and those taught using conventional method.

### Research Question Two

What is the difference between the mean achievement scores of chemistry students with field dependent and field independent cognitive styles when collaborative instructional strategy is used?

**Table 3: Mean and Standard Deviation Scores of Students with Field Dependent and Field Independent Cognitive Styles**

Group	N	Pre-test		Post-test		Mean gain
		Mean	SD	mean	SD	
Field Dept.	50	34.00	9.01	48.98	13.85	14.98
Field Indept.	34	35.10	9.20	62.00	13.39	26.9
Mean Difference		1.10		18.45		11.92

Result in Table 3 reveals that students with field dependent cognitive style have a mean achievement score of 34.00 in pretest and 48.98 in posttest and standard deviation of 9.01 in pretest and 13.85 in post-test while those with Field independent cognitive style have a mean achievement score of 35.10 in pretest and 62.00 in posttest and standard deviation of 9.20 in pretest and 13.39 in posttest. The mean gain for field dependent students was 14.98 while that of the field independent was 26.9. The mean difference was 18.45 in favour of the field independent group. Therefore, the difference between the mean achievement scores of chemistry students with field dependent and field independent cognitive styles when collaborative instructional strategy is used was 18.45.

### Hypothesis Two

There is no significant difference between the mean achievement scores of chemistry students with field dependent and field independent cognitive styles when collaborative instructional strategy is used.

**Table 4: ANCOVA Result of chemistry Students with Field-dependent and Field-independent Achievement when Taught Chemistry Using Collaborative Instructional Strategy and Those Taught Using the Conventional Method**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	13590.24	2	6795.12	106.51	.000
Intercept	12057.20	1	12057.20	188.99	.000
Achprt	10159.47	1	10159.47	159.25	.000
Cogst	347.95	1	347.9	5.45	.022
Error	5167.50	81	63.79		
Total	265975.00	84			
Corrected Total	48012.136	83			

a. R Squared = .555 (adjusted R Square = .549)

Table 4 reveals that  $F(1,63.79)=5.45$  with p-value of 0.02 which is less than 0.05 level of significant set for this study. The hypothesis is therefore rejected. This implies that there is a significant difference between the mean achievement scores of chemistry students with field dependent and field independent cognitive styles when collaborative instructional strategy is used.

## Discussion of Findings

The first finding indicates that there is a significant difference between the mean achievement scores of students taught chemistry using collaborative instructional strategy and those taught using conventional method. This finding is in agreement with that of Okeke and Okey (2018) and Jirgba, Eriba and Achor (2018) who also found that students who studied chemistry using collaborative learning strategy achieved better than those with the lecture based method. This finding is possible because students who engaged in collaborative learning strategy capitalize on one another's resources and skills through asking one another questions for information, evaluating one another's ideas, monitoring one another's work which improves their performance. This finding also corroborates the assertion by Many (2011) that students are able to achieve higher levels of learning and retain more information when they work in a group rather than individually, this applies to both the facilitators of knowledge, the instructors, and the receivers of knowledge who are the students. This finding however disagreed with the earlier finding by Williams and Akpan (2017) who found that there was no significant difference in the mean scores of students who were taught using collaborative approach and those who were taught using the conventional method. The present findings offer further support for the use of the collaborative instructional method. This finding disagreed with that of Williams and Akpan (2017) because of differences in the cultural background of the students. The two states, Rivers and Benue States where the two studies were conducted have great variations in the cultural, ethnic and religious background which could be responsible for the differences in the findings.

The findings equally revealed that there is a significant difference in the mean achievement scores of chemistry students with field dependent and field independent cognitive styles when collaborative instructional strategy is used. This implies that students with field independent cognitive styles have higher scores than the field dependent cognitive styles. This finding support the earlier finding by Idika (2017) who found that there was significant main difference between field dependent and field independent students' achievement in chemistry, students with field independent level of cognitive style obtained higher mean score of chemistry achievement than those with field dependent level of cognitive style. This finding also collaborates that of Yu (2016) who indicated that there was a significant correlation between field-dependent and field-independent cognitive styles and science and mathematics achievement and field-independent students are more successful than their field dependent peers in both courses. This finding is possible because field independent students are more analytical than field dependent learners. Being analytical is necessary for success in chemistry particularly and science in general.

## Conclusion

In this study the use of collaborative instructional strategy enhanced students' achievement in chemistry more than the conventional method. The use of collaborative instructional strategy also favoured students with field-independent cognitive styles more than the field-dependent cognitive styles.

## Recommendations

Based on the findings, the following recommendations are made:

- i. Chemistry teachers should use collaborative instructional strategy as it provides students with opportunity to interact with their peers and enhance their achievement in Chemistry.
- ii. Chemistry teachers should use collaborative instructional strategy as it favours both field-dependent and field-independent cognitive styles.
- iii. Educational stakeholders (Ministry of education, Teaching Service Board, Universal Basic Education Board, UNICEF etc.) should organize workshops for re-training of in-service teachers on the use of collaborative instructional strategy.

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