# The Factor of Cognitive Styles in Mathematical Performance of Senior Secondary School Students in Osun State, Nigeria

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*Abstract*

*The study examined the types of cognitive styles exhibited by senior secondary school students in Osun State and examined how these styles influence students' performance in Mathematics. The interaction of sex with these styles to influence performance was also examined. A sample of 720 senior secondary two students was involved in the study using the ex-post facto design. Two instruments namely Group Embedded Figures Test (GEFT) and Achievement Test in Mathematics (ATM) were used. Findings of the study showed that the students exhibited field dependent versus field independent cognitive styles. A significant difference occurred in the Mathematics performance between field dependent and field independent students ($t= 37.63$, $df = 718$, $p< 0.05$). Likewise performance of male and female students who exhibited field-dependence style differed significantly ($t= 7.24$, $df = 336$, $p < 0.05$). The study, therefore, concluded that cognitive style influences students' performance in Mathematics.*

## Introduction

Students' performance in Mathematics over the years in Africa has not been satisfactory especially despite the importance of the subject (Mbugua, Kibet, Muthaa, Nkonke, 2012). Aworonye and Betiku (1993) noted that Science, Technology and Mathematics Education (STME) are the bedrock of technological development of any economy and that Mathematics is a necessary requirement for most disciplines (both sciences and humanities) in higher institutions of learning. In a reaction to this unsatisfactory students' performance in Mathematics, Mathematical Association of Nigeria (MAN) and other concerned stake holders have been making untiring efforts to find ways of improving the teaching and learning of Mathematics by organising annual seminars and workshops for Mathematics teachers. Such efforts also include the annual Teachers Vacation Course (TVC) organised by The Federal Ministry of Education, Abuja. Researchers (Kadiri, 2004; Adeleke, 2005; Adeleke and Oloyede, 2009, Felder, 2010) have also come up with or reported various innovative teaching strategies that can help improve mathematics and which have still not yielded expected results. Despite all the laudable efforts, the poor performance of Nigerian students in Mathematics persists. The Study of Lamb and Fuljarton, (2002) on differences in Mathematics performance have highlighted the importance of classroom, teacher, students personal and school factors. One of the integral components of students' personal factors in an assessment of performance in mathematics that requires investigation is individual's cognitive style. According to Witkin, (1973), cognitive style is a potent variable in students' academic choices and vocational preferences; in students academic development through their school career; in how students learn and teachers teach and in how students and teachers interact in the classroom.

Cognitive styles also refer to the characteristic modes of functioning that individuals show in perceptual and intellectual activities in highly consistent and pervasive ways (Witkin and Goodenough, 1977 and Thornell, 1976). Furthermore, cognitive styles deal with

skills in performing or solving a task (Ojo, 2010). Such skills include visualization, association, abstraction, comprehension, manipulation, reasoning, analysis, synthesis, generalization, which need to be managed and coordinated (Garafalo and Lester, 1985). If all of these identified characteristics or attributes of cognitive style are lacking in teaching and learning process, there may be problem of poor performance.

Price (2004) was of the view that students have different ways of approaching or solving problems due to differences in higher order thinking skills such as visualization, association, abstraction, comprehension, mani-pulation, reasoning, analysis, synthesis, generalization and individual differences. While some students learn or solve problems at slow rate, others act quickly. This shows that individual differences exist as a result of cognitive styles possessed by the learners. There is, therefore, the need to find out the difference in students' performance in mathematics as a result of difference in cognitive styles so that teachers can be well equipped in the discharge of their duties. A review of teaching principles from the Principles and Standards for School Mathematics (PSSM) reveal that effective Mathematics teaching requires understanding what students know and need to learn and then challenging and supporting them to learn it well (NCTM, 2000). So, it is the duty of Mathematics teachers to teach their students newly required knowledge that will be based on their previous knowledge.

In the opinion of Adeyanju (1995), Isyaku and Kalgo (1996), in terms of school achievement, field independent students have been found to achieve significantly better in science and Mathematics than field dependent students as a result of different abilities whereas Adegoke (2011) found that field dependence-independence does not influence students' ability to learn but that it may make students respond differently to learning as a result of different learning environment. These are two research findings that are not in the same direction. A situation like this warrants further investigation.

Ball (2000) shows that a command of subject is a necessary condition for effective teaching; he established that it is not sufficient without the content knowledge of how to make Mathematics contents meaningful for students understanding. Thus, competent Mathematics teachers exhibited progressively more pedagogical content knowledge as they were exposed to Mathematics pedagogy during their Mathematics methods course. This indicates that teachers with adequate Mathematics basic knowledge always understand how knowledge is constructed especially as it relates to the way learners construct meaning. They will have the solid Mathematical preparation needed to teach Mathematics to students successfully. The teachers must also have a solid understanding of pedagogical practices that help make content vivid and memorable as well as practices that will pique the learners' interest, relate to their background experiences and maturate them to learn (Shulman 1986). Effective teachers must have a profound understanding of Mathematics content knowledge. This is necessary because effective teachers are able to guide their students from their current understandings to further learning and prepare them for future travel (National Research Council 2001). One way by which the teacher can do this is perhaps to be able to identify the cognitive style of his/her students and work with it. Messick (1996) identified as many as nine types of cognitive styles:

(i) Field independence versus field dependence is described as analytical rather than a global way of perceiving. It entails a tendency to experience items as discrete from their backgrounds and reflects ability to overcome the influence of an embedding context.

(ii) Cognitive complexity versus simplicity refers to individual differences in the tendency to construe the world; and particularly the words of social behaviour, in a

multidimensional and incriminating way.

(iii) Levelling versus sharpening describes reliable individual variations in assimilation in memory. Students at the levelling extreme tend to blur similar memories and merge perceived objects or events that are similar but not for identical events recalled from previous experience. Sharpeners at the other extreme are less prone to confuse similar objects.

(iv) Breadth of categorizing – explains consistent preferences for broad inclusiveness, as opposed to narrow exclusiveness in establishing the acceptance range for specified categories. Some learners adopt this style of learning and often times learn very little.

(v) Tolerance of incongruous or unrealistic experiences as explained is a dimension of differential willingness to accept perceptions at variance with conventional experience. The dimension selected for this study, is field dependence and field – independence.

(vi) Scanning is also a cognitive style that describes a dimension of individual variations in vividness of experience and the span of awareness. Some children learn by scanning materials, in this case, much of what should be learned is lost.

(vii). Conceptualizing styles – exhibit the individual differences. It is the tendency to categorize perceived similarities and differences among stimuli in terms of many differential concepts which is a dimension called conceptual differentiation. This technique of learning also refers to consistencies in the utilization of particular conceptualizing approaches as bases for forming concepts such as the routine use in concept formation of thematic or functional relations among stimuli as opposed to the analysis of descriptive attributes or the inference of class membership.

(viii) Reflectiveness versus impulsivity explains individual consistencies in the speed with which hypotheses are selected and information processed. With impulsive subjects they tend to offer the first answers that occurs to them, even though it is frequently incorrect. Reflective subjects tend to ponder various possibilities before deciding. This cognitive style also demands, the teacher's patience in guiding learners.

(ix) Constricted versus flexible control describes individual differences in susceptibility to distraction and cognitive interference. A careful look at the various styles highlighted shows that many of the other styles are embedded in the requirements of the field dependence-independence category. Being analytical or global entails the features that are described in the other styles. Ability to view events, contents or tasks within or outside of the embedding context would demand individual's cognitive complexity, level of assimilation, experience and individual consistency in learning. These are the features of the other styles. Field dependence-independence categorization is therefore germane for investigation.

**Statement of the Problem**

Research has indicated a strong connection between cognitive style and performance in mathematics. However, studies have remained inconclusive on this. The observation that the different instructional strategies or decisions employed in teaching mathematics have not improved students' performance in the subject to any appreciable extent clearly points out that the search for reasons for poor performance and efforts to improve it should continue. Student's cognitive style

being a potent factor that could interfere with teacher's teaching strategy therefore requires further investigation.

**Purpose of the Study**

The purpose of the study is to find out the influence of cognitive styles on performance in mathematics. The specific objectives of this study are to:

(i) identify the cognitive styles of students in mathematics;

(ii) examine the difference in students' performance as a result of difference in cognitive styles; and

(iii) investigate the influence of the interaction of gender and cognitive style on performance in mathematics.

**Research Question**

What types of cognitive style are exhibited by students in senior secondary schools in Osun State?

**Hypotheses of the Study**

The following null hypotheses were generated to guide the study.

(i) There is no significant main effect of cognitive style on the performance of students in mathematics.

(ii) There is no significant interaction effect of gender and cognitive style on students' performance in mathematics.

**Theoretical Framework**

Theoretical framework for this study was based on Cognitive Control Theory, (Jonassen & Grabowski, 1993). This theory posits that cognitive controls are the psychoanalytic entities that regulate perception. It clarifies that cognitive styles define learner traits, and the control components of the styles have the status of intervening variables that define principles by which motoric behavior, perception, memory and other basic quantitative forms of cognitive functioning are organized as an individual coordinates himself with his/her environment. Bandura (2001) buttresses this by stressing that behaviour is determined not only by environmental conditions but also by how thoughts modify the effects of environment on behaviours. Cognitive theorists believe that imitation is one of the main ways in which we learn about our environment. Therefore, to produce a model behaviour we must enter and store the information in the memory, which is known as mental (cognitive) process The cognitive theorists believe that the learner has inherent and qualitative capability which enables him/her to participate actively in the process of learning.

According to Jonassen & Grabowski (1993), cognitive control theory explains that field dependence-independence describes the extent to which:

(i) The surrounding framework dominates the perception of items within it,

(ii) The surrounding organized field influences a person's perception of items within it,

(iii) A person perceives part of the field as a discrete form,

(iv) The organization of the prevailing field determines the perception of its components, or

(v) A person perceives analytically( p. 86).

This explanation further emphasizes how significant field-dependence/independence style can be in determining extent of learning in mathematics and the need for a further investigation.

**Methodology**

The ex-post facto research design was used in this study to obtain information on the students' cognitive styles and performance in mathematics. The instruments were administered to some of the members of the population considered to be representative of its entire population.

The population for this study consisted of senior secondary school two (SSII) mathematics students in Osun State of Nigeria in 2010/2011 academic session. Seven hundred and twenty SSII students were selected from the population by multistage random sampling from six local government areas which were randomly chosen from 30 local government areas in the State. From each local government area, two schools were randomly selected while 60 students were randomly selected from each school.

Two instruments were used for the study. They are:

i. Group Embedded Figures Test (GEFT) (adapted from Witkin, Raskin and Oltman 1971) used to obtain information on field independent and field dependent cognitive styles of students.
ii. Achievement Test in Mathematics (ATM) used to obtain information on students' performance in mathematics which consisted of 25 item multiple choice questions each with alternatives a, b, c and d. The research instruments were validated for face and content validity as well as for reliability. Split half method was used for GEFT while Kuder Richardson K-R 21 was used for ATM. GEFT had reliability coefficient of 0.82 and ATM had 0.65.

The GEFT was administered to identify the cognitive style of the students based on the students' scores and as guided by Witkin's recommendation. ATM was used to assess students' performance in mathematics. All hypotheses were tested at 0.05 level of significance using t-test statistic.

**Results**

**Research Question:**

What types of cognitive style are exhibited by students in senior secondary schools?

This research question was raised to determine the prevalence of field dependence/independence among the students. Summary of the data obtained is presented in table1

**Table 1**
**Frequency distribution of students' scores on the Group Embedded Figures Test (GEFT) N=720.**

| GEFT Scores | Frequency | Total Frequency | Nature of Cognitive Style |
|---|---|---|---|
| 0 | 10 | | |
| 1 | 12 | | |
| 2 | 14 | | |
| 3 | 24 | | |
| 4 | 28 | 382 | Field Dependent |
| 5 | 70 | | |
| 6 | 87 | | |
| 7 | 137 | | |
| 8 | 134 | | |
| 9 | 148 | 338 | Field Independent |
| 10 | 56 | | |

The analysis of Table 3 classified the students' cognitive styles into two groups viz those who scored 7 and below are field dependent students (non –analytic style) and those who scored 8 and above are field independent students (analytic style). And it shows that the number of field independent students is less than the number of field dependant students. This only shows that field dependent students are more than field independent students in senior secondary schools.

**Hypothesis one:**

There is no significant difference in the performance of students in mathematics irrespective of their cognitive styles. This hypothesis was to find out the difference in the mathematical performance of the students as a result of difference in cognitive style. Analysis of data collected is as shown in table 2

**Table 2**
**T– test analysis of the performance of field-independent and field-dependent students in Mathematics**

| Cognitive style | N | X | s.d | Df | t-cal | t-critical |
|---|---|---|---|---|---|---|
| Field independent | 338 | 23.19 | 3.29 | 718 | 37.63 | 1.64 |
| Field dependent | 382 | 13.86 | 3.34 | | | |

$p < 0.05$.

The analysis in Table 2 shows that students who exhibited field independence performed better in mathematics than those with field dependence style. This difference was found to be significantly different when subjected to t-test analysis ($t=37.63$, $df=718$, $p<0.05$).

**Hypothesis two:**
There is no significance difference in the performance of male and female students in mathematics based on their cognitive styles. The essence of this hypothesis was to find out the difference in students' performance in mathematics as a result of the combined difference in sex and cognitive style. The analysis is shown in Tables 3 and 4.

**Table 3**
**T-test analysis of the performance of male and female students who are field independent**

| Field independent | N | X | s.d | df | t-cal | t-critical |
|---|---|---|---|---|---|---|
| Male | 210 | 24.14 | 2.66 | 336 | 7.24 | 1.64 |
| Female | 128 | 21.63 | 3.67 | | | |

$p < 0.05$.

The analysis in Table 3 shows that the calculated t – value of 7.24 was greater than the critical t-value of 1.64 at $p < 0.05$ alpha level. Therefore, the null hypothesis was rejected. This implies that there was a significant difference between the performance of male field independent students and female field independent students in mathematics.

**Table 4**
**T – test analysis of the performance of male and female students who are field dependent**

| Field dependent | N | x | SD | df | t-calculated | t-critical |
|---|---|---|---|---|---|---|
| Male | 152 | 14.75 | 2.48 | 380 | 0.22 | 1.64 |
| Female | 230 | 13.27 | 3.69 | | | |

$p < 0.05$ alpha level

The analysis in Table 4 shows that the calculated t – value of 0.22 was less than the critical t-value of 1.64 at $p > 0.05$ alpha level. Therefore, the null hypothesis was upheld. This implies that there was no significant difference between the performance of male field dependent students and female field dependent students in mathematics.

**Discussion**
This study reported an existence of field dependence versus field independence among senior secondary school students and that the performance of field

independent students was better than that of the field dependent in mathematics. The better performance of the field independent students could be attributed to the fact that field independent students are more analytical in problem solving due to the features of field independence. This finding corroborates that of Lu and Suen, (1995), where it was reported that field independent students achieved more on performance-based assessments than did field dependent students. Likewise Babalola (1979) and Adeyanju (1985) discovered that the field independent pupils were superior in most subjects offered in primary and secondary schools. Obinaju (2012) was of the view that field independent people tend to perform better on most cognitive tests especially spatial ones than do field dependent people. In the same vein Adeyanju (1995), Isyaku and Kalgo (1996) had found that, in terms of school achievement, field independent students have been found to achieve significantly better in science and mathematics than field dependent students. They added that this is because field independent students have an advantage over field dependent students for being more analytical.

The study also found a significant difference between the performance of male field independent students and female field independent students in mathematics. Thus, reaffirming the earlier findings that performance in mathematics is related to sex. This result is in agreement with the findings of Adeyanju (1996) that boys more than girls are field independent.

A non-significant difference between the performance of male field dependent students and female field dependent students in mathematics was also reported in this study. The seemingly inconclusive findings on the superiority position between boys and girls in science and mathematics has again resurfaced in this study. The study by Ehindero, Adeleke, Oloyede and Ajibade (2009) reported that superiority between boys and girls is not general. Classroom arrangement for teaching and learning as well as contents involved can be moderating factors. This study has found ut that cognitive style can also be another moderating factor where field dependence can bring about boys superiority over girls in mathematics and field dependence account for no difference in the performance of boys and girls.

From the findings of this research, it can be said that the idea of identifying students' cognitive styles will assist the classroom teachers to make a proper and resourceful decision in planning appropriate contents and teaching instructions for learners of varied abilities of using thinking skills such as visualization, abstraction, association, comprehension, mani-pulation, reasoning ability, analysis, synthesis and generalization. This practice may enhance better performance of individual students and greatly reduce the rate of poor performance recorded yearly in Mathematics.

## Conclusion

The study concluded that cognitive style affects students' learning of mathematics. Findings have therefore added to the volume of literature in support of the position that field dependence-independence cognitive style affects learning of mathematics as a result of differential learning abilities.

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