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Relationship Among Cognitive Styles, Learning Strategy and Students Performance in Mathematics

Morenikeji A. AKANMU
University of Ilorin, Ilorin, Nigeria.

and

Michael O. FAJEMIDAGBA
University of Ilorin, Ilorin, Nigeria.

Abstract

This study investigated the relationship among cognitive styles, learning strategy and performance of senior school students in General Mathematics. Also, the interaction effect of the treatment and cognitive styles of the students was investigated. Two groups of students participated. The experimental groups were exposed to guided-discovery learning strategy and the control group without guided-discovery learning strategy. Three research questions were formulated to guide the study and the corresponding hypotheses were tested using t-test statistics and Analysis of Covariance (ANCOVA). The sample comprised 202 SS1 students from intact classes of two purposively selected secondary schools from Ejigbo Local Government Area of Osun State. The scores of the pre-test modified Group Embedded Figures Test administered to the students was used to assign them into the two cognitive styles treatment groups (Field dependent and field-independent) and the main instrument for data collection was Mathematics Achievement Test (MAT) which consisted of questions on Set Theory that were set by the West African Examinations Council (WAEC), that is, past questions used to evaluate Senior School students. The findings of the study revealed that there is a significant difference in the performance of students categorized into field dependent and field independent students when exposed to guided-discovery learning strategy. The outcome was in favour of field-independent students. Recommendation were made based on the findings.

Introduction

Mathematics serves as a bridge between the sensible and the intelligible, the visible sensible squares and triangles are suggestive and lead to intelligible deductions (Asim, Bassey & Essien, 2005). As a theoretical discipline, mathematics explores the possible relationships among abstractions without concern for whether those abstractions have counterparts in the physical world.

The abstractions can be anything from strings of numbers to geometric figures to sets of equations.

Mathematics relies on both logic and creativity, and it is pursued both for a variety of practical purposes and for its intrinsic interest. According to Akinsola (2002), Mathematics did not only empower people with the capacity to control their lives but also provided a firm foundation for theories in sciences as it guarantees societies vigorous economies. The depth of mathematical knowledge an individual has, determines the level of accuracy of his/her decision. In their submission, Voderman, Porkess, Budd, Dunne and Rahman-Hart (2011) opined that mathematics is 'the only truly universal language and it is an essential part of our personal and working life'. They stated further that *without a secure understanding of mathematics, musical composition and architectural design are impossible*. This implies the fact that before an individual can function well in the society, he/she must possess or have relatively good knowledge of mathematics especially in this era of technological development which is highly rooted in the study of mathematics. Being a basic tool needed for effective daily functioning, both scientific breakthrough and technological development are facilitated by the precise language of mathematics. Subsequently, the interest in raising levels of performance as well as understanding of mathematics considering repeated poor performance of students in internal and external examinations and findings of empirical studies in recent times make it increasingly clear that further investigation is required.

Background of the Study

It has been noted that without mathematics there is no science and without science both scientific breakthrough and technological development will never be possible. However, one specific issue which has generated much debate in the quest for attainment of set scientific breakthrough is whether differential cognitive styles of learners exist or does not exist between male and female and if it does, whether it affects learners response in a defined task. It has recorded varying degrees of interest with the number of studies carried out because both the empirical and theoretical literature have produced diverse and contradictory results. Much of the earlier studies (e.g. Maccoby and Jacklin, 1974) has reported that males have better Mathematics and visuospatial skills than females. Maccoby (1987) maintained that males still have superior skills in Mathematics and visuospatials than the females.

Hyde and Mezulis (2001) believed that the cognitive differences between males and females have been exaggerated. Indeed, Hyde (1993) pointed out that there is considerable overlap in the distribution of male and female scores on mathematics and visuospatial tasks. Jegede and Inyang (1990) however opined that with recent interest in comparing achievement of males and females in mathematics and sciences, where differences are observed, inevitably, there should be a debate in

determining whether those differences are due to cognitive difference and/or social and cultural stereotyping. They remarked that gender differences is an area of educational research that has generated conflicting and non-conclusive finding world over. Therefore, this study investigated the relationship among cognitive styles, learning strategy and performance of senior school students' performance in General Mathematics in Ejigbo Local Government Area of Osun State. The interaction effect of the treatment and cognitive styles of the students was also considered.

Research Hypotheses

The following null hypotheses were tested in this study:

- HO₁: There would be no significant difference in the mean gain scores of field-dependent and field-independent students when taught using guided-discovery learning strategy.
- HO₂: There would be no significant difference in the mean gain scores of male and female students in mathematics when they are taught using guided-discovery learning strategy.
- HO₃: There would be no significant interaction effect between the treatment and the cognitive style on the performance of students in mathematics.

Research Methodology

This study was a quasi-experimental research designed to determine the relationship among cognitive styles, learning strategy and learners' achievement in mathematics. Being a distinctive and specific approach, the pre-test and post-test control group design of 2 x 2 experimental design was employed for this study. The experimental levels are as follows: cognitive styles at 2 levels (field-dependent and field-independent) and learning strategies at 2 levels (guided-discovery and non-guided-discovery). The interaction effect of the treatment was also considered. A total of 202 students from the two purposively selected Schools participated. Details of the students that participated in the study in line with research design is reported in tables 1 and 2.

Table 1: *Sampling frame for the students that participated in the Experimental group*

Label	No	M	F	LS-M	MS-M	HS-M	LS-F	MS-F	HS-F
Field-dependent	29	16	13	0	1	15	0	1	12
Field-independent	61	30	31	3	24	3	3	25	3

Table 2: Sampling frame for the students that participated in the control group

Label	No	M	F	LS-M	MS-M	HS-M	LS-F	MS-F	HS-F
Field-dependent	17	8	9	0	4	4	0	3	6
Field-independent	95	65	30	3	59	3	2	27	1

Key:

M: Male and F: Female;

LS-M : low scorers (Male), MS-M: medium scorers (male) and HS-M: high scorers (male); and

LS-F: low scorers (female), MS-F: medium scorers (female) and HS-F: high scorers (male).

Research Instruments

Group Embedded Figures Test (GEFT) was adopted for this study. There were two reasons for choosing GEFT in this study. First, the instrument is a non-verbal test and requires only a minimum level of language skill for performing the tasks (Cakan, 2003). Another reason was that psychometrical properties of the instrument had been investigated in cross-cultural settings and accepted as quite reasonable. The instrument required each individual to trace a specified simple figure that was embedded within a complex design. The test consisted of two sections. The first section which consisted of 4 items was earlier given for practice purposes. The second section contained 10 items. The total time for completing the test was 20 minutes. The possible score ranged from 0 to 20. The 10-item GEFT was used to assign students into field-dependent and field-independent categories. The field-independent cognitive style involves students ability to distinguish relevant mathematics concepts from complex task situations. The ability of the learners to carry out this effectively categorizes them as field-independent. On the other hand, the field-dependent students are not able to disseminate relevant mathematics concepts from a complex background. For each item, a score of two or zero is awarded if the GEFT form is correctly or wrongly outlined respectively. A score of 0-9 indicates field-dependent while a score of 10-20 represents field-independent students.

In line with the established GEFT, the main instrument that was used after the successful classification into groups is Mathematics Achievement Test (MAT). The Mathematics Achievement Test contained twenty multiple choice questions

drawn from the West Africa Senior School Certificate Mathematics Examinations questions. The MAT consists of 20 items multiple choice test mainly on Set theory. The test was used to determine the academic ability of the field-dependent and field-independent students in mathematics. Minimum and maximum scores of 0 and 20 were expected respectively to be the range within which the performance of both groups should fall (0-6 categorized as low scoring, 7-13 categorized as medium scoring and 14-20 as High scoring students).

The instructional instruments were lesson plans drawn on guided-discovery learning strategy and non guided-discovery strategy in teaching the experimental and control group respectively. The guided-discovery learning strategy was student-activity centred which required a lot of interaction among the researcher, students and instructional materials.

The control group was taught using the non guided-discovery mode only, that is, the group was exposed only to lecture method. Instructions were highly verbalized with minimum interaction between students and instructional materials.

Two periods of forty (40) minutes was spent each week throughout the treatment period. The study lasted for six (6) weeks of three (3) weeks teaching while first, second and the last week were used for preparation, pre-test and post-testing respectively.

Results

Three research questions were raised and the three corresponding hypotheses were tested using t-test statistics for hypotheses one and two and Analysis of Covariance (ANCOVA) for hypothesis three respectively.

H₀₁: There would be no significant difference in the mean post-test scores of field-dependent and field-independent students when taught using guided-discovery learning strategy.

Table 3:

The t-Test Analysis showing difference in the mean post-test scores of field dependent (FD) and field independent(FID) students when taught using guided-discovery learning strategy

Variables	No	Mean= $\bar{x}$	Std	df	t-value	Sig
FD	61	13.4918	2.71798	88	3.348	.001
FID	29	15.2759	1.30648			

$P < 0.05$

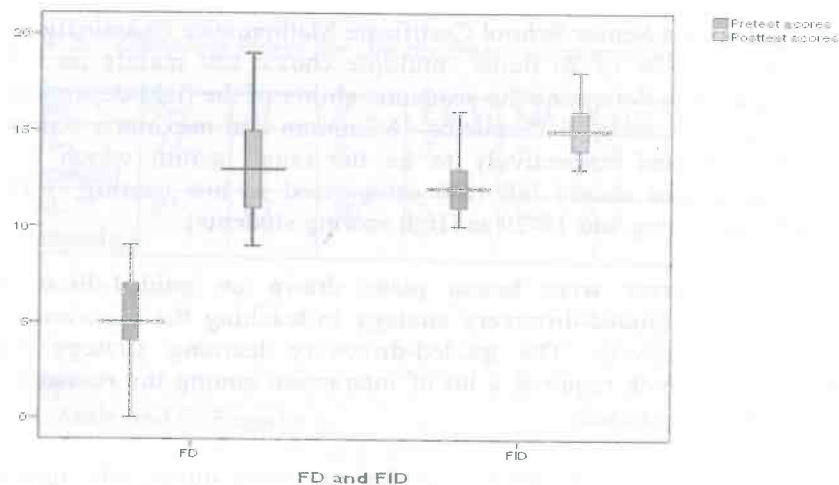


Figure 1: Box and Whiskers Plot of the FD and FID post-test Scores (Experimental)

Table 3 shows that the calculated t-value = 3.348 with p-value of $.001 < 0.05$ alpha level. It implies that the null hypothesis one was rejected and the alternative hypothesis that, there would be a significant difference in the mean post-test scores of field-dependent and field-independent students when taught using guided-discovery learning strategy is accepted. To further ascertain where lies the significant difference, the mean scores of the field-dependent and field-independent students were compared and it was found that it was in favour of the field-independent students. The mean scores obtained for the field-dependent is (15.2759) which is greater than the mean scores (13.4918) obtained in respect of the field-dependent students.

Figure 1 also shows that field-independent students performed better than their field-dependent counterparts in both pre-test and post-test scores.

H₀₂: There would be no significant difference in the post-test mean scores of male and female students in Mathematics when they are taught using guided-discovery learning strategy.

Table 4: The t-Test Analysis showing difference in post-test mean scores of male and female students in Mathematics when they were taught using guided-discovery learning strategy

Variables	No	Mean	std	df	t-value	Sig
Male	46	14.0652	2.58545	88	.168	.867
Female	44	13.9767	2.37535			

$P < 0.05$

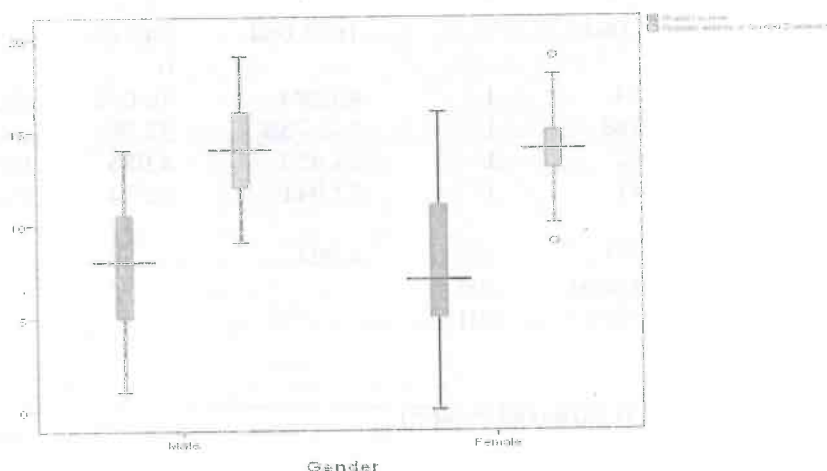


Figure 2: Box and Whiskers Plot of the Male and Female post-test Scores (Experimental)

From Table 4, analysis reveals that the calculated t -value = .168 with p value of .867 > 0.05 alpha level. It implies that the null hypothesis two which state that there would be no significant difference in post-test mean scores of male and female students in Mathematics when they are taught using guided-discovery learning strategy was not rejected. In other words, the performance of male and female students taught using guided-discovery learning strategy shows no difference. Hence, the hypothesis is upheld.

From figure 2, within each gender group, the post-test scores is higher than the pre-test scores but across the gender groups, there is no statistical difference between each test scores. The pre-test and post-test scores for male and female were apparently similar. The main gain scores for male = 14.0652 while the mean gain score for female = 13.9767. The mean scores obtained for male and female in field-dependent were 5.5667 and 5.0968 respectively. For the field-independent, 11.6250 and 12.3846 was obtained as mean scores for male and female in the group.

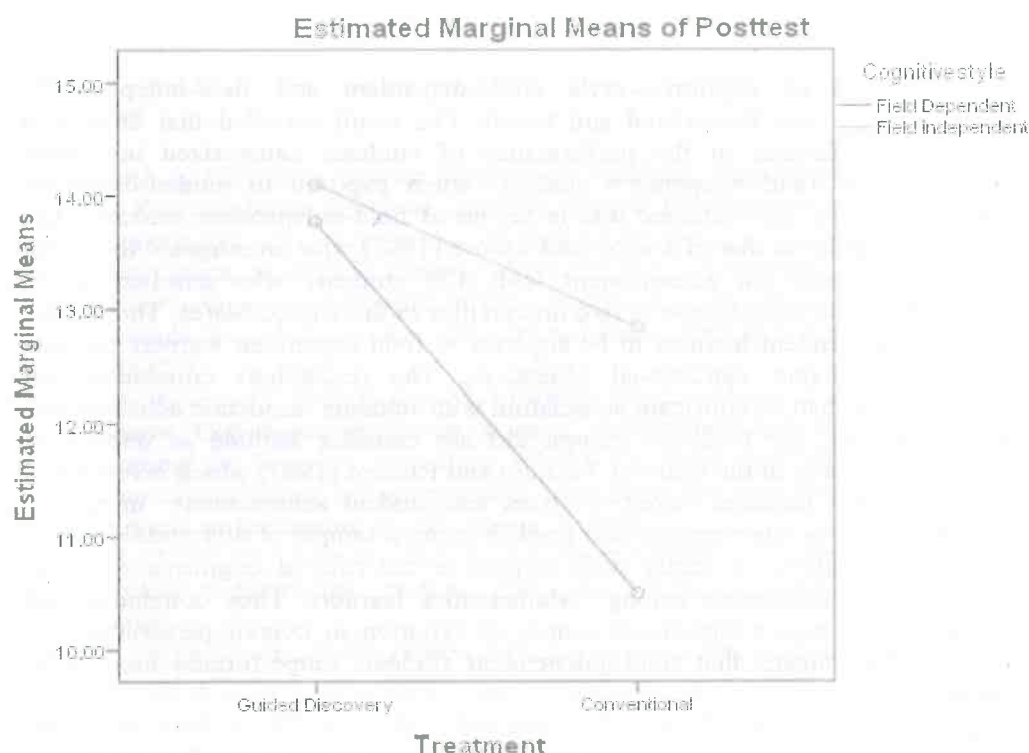
HO₃: There would be no significant interaction effect between the treatment and the cognitive style on the performance of students in Mathematics.

Table 5: ANCOVA Computation on Post-test Mean Scores of Students in the Treatment Group and Cognitive style

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	876.820 ^a	4	219.205	44.702	.000
Intercept	1685.064	1	1685.064	343.63	.000
Pretest	49.284	1	49.284	10.050	.002
Treatment	161.788	1	161.788	32.993	.000
Cognitive style	24.452	1	24.452	4.986	.027
Treatment * Cognitive style	32.041	1	32.041	6.534	.011
Error	966.031	197	4.904		
Total	31850.000	202			
Corrected Total	1842.851	201			

a. R Squared = .476 (Adjusted R Squared = .465)

Table 5 showed that at $F(1, 197) = 6.534$, $p < 0.005$, the null hypothesis was rejected. Hence, there was significant interaction effect between the treatment and the cognitive style of the students. The profile plot is shown in figure 3.



Covariates appearing in the model are evaluated at the following values: pretest = 6.4653

Figure 3: Graph on the interaction effect between the treatment and the students' Cognitive Style

Summary of Major Findings

The following are the summary of major findings in this study:

1. the post test mean scores of the field-independent students were significantly higher than the post test mean scores of the field-dependent students when taught using guided-discovery learning strategy,
2. post test mean scores of male students was not significantly higher than that of the female students when taught using guided-discovery learning strategy, and
3. there was significant interaction effect between the treatment and the cognitive style of the students, $F(1, 197) = 6.534, p < 0.05$.

Conclusion

On the effect of cognitive style (field-dependent and field-independent), hypothesis one was formulated and tested. The result revealed that there is a significant difference in the performance of students categorized into field dependent and field-independent students when exposed to guided-discovery learning strategy. The outcome was in favour of field-independent students. The result was similar to that of Dwyer and Moore (1995) who investigated the effect of cognitive style on achievement with 179 students who enrolled in an introductory education course at two universities in the United States. They found the field-independent learners to be superior to field-dependent learners on tests measuring different educational objectives. The researchers concluded that cognitive style had a significant association with students' academic achievement. In like manner, the findings, though did not consider attitude as one of its variables, as it was in the study of Tinajero and Paramo (1997) which investigated the relationship between cognitive styles and student achievement in several subjects including Mathematics and English using a sample of 408 middle school students but enjoys similarity with respect to the role of cognitive styles as predictor of achievement among Mathematics learners. They concluded that cognitive style was a significant source of variation in overall performance of students. This means that field-independent students outperformed their field-dependent counterparts. These findings were not in agreement with the findings of Altun and Cakan (2006) who assessed the correlation between field-dependency and attitude towards computers among 130 undergraduate students. The study also revealed that both male and female Students benefitted equally when exposed to guided-discovery learning strategy.

Recommendations

In line with the findings of this study, the following are recommended:

1. Guided-Discovery Learning was found helpful in learners' ability to extract a simple figure from a complex one since it was more interactive. Mathematics teachers should make the teaching-learning of Mathematics an interactive and activity-based for the students. Hence, guided-discovery learning is recommended in addition to other methods especially when teaching set theory, so that all students could gain from the teaching irrespective of the ability levels of the students.
2. Male and females should have roles to play in Mathematics class since males are not superior to females in Mathematics class as found from this study.
3. Ministries of Education at both Federal and State levels should periodically organize regular workshops for teachers for reviewing / assessing the impact of teaching methods.

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