

## **EFFECT OF LESSON STUDY ON SENIOR SECONDARY SCHOOL STUDENTS' ACHIEVEMENT IN MATHEMATICS**

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### **Abstract**

*There is no gainsaying that students' performance in mathematics in both internal and national examinations in Nigeria is at a low ebb. This low level of performance demands that a review of the strategies for the teaching and learning of the subject be done. In an attempt to remediate this situation, the study investigated the effect of lesson study on senior secondary school students' achievement in mathematics. The quasi-experimental pre-test, post-test non-equivalent control group research design was adopted for the study which involved a total of 310 students (141 males and 169 females). The instrument for data collection was the adopted Group Embedded Figures Test and a validated Mathematics Achievement Test. Analysis of data gathered revealed that there was a significant main effect of treatment on students' achievement in mathematics in favour of the lesson study strategy. The field dependent students benefitted more than the field independent students while male students also achieved better than their female counterparts. However, cognitive style and gender did not have significant main effects on students' achievement in mathematics. The interaction effects of treatment and cognitive style, treatment and gender, gender and cognitive style as well as treatment, gender and cognitive style were all observed to be statistically non-significant. Recommendations included that teachers should embrace lesson study in developing mathematics lesson plans to enhance students' learning of the subject and they should attempt to identify the cognitive style of their students so that they will know how best to teach them.*

**Keywords:** Lesson study, cognitive style, gender, achievement, mathematics

### **Introduction**

Mathematics is a subject with wide applications in daily life and career progression. Its importance cannot be overemphasized as it furnishes learners with matchlessly influential tools to describe, investigate and transform the universe (Awofala, 2010). Odumosu, Oluwayemi and Olatunde (2012) supported this assertion when they observed that there is hardly any area of science that does not make use of mathematical knowledge to explain the concepts, theories or models.

Mathematics occupies a pivotal position in science and technology and is needed by everybody and in every aspect of human endeavour (Abubakar & Uboh, 2010). It requires concentration, importunity and focus due to its rigorous and problem solving nature. It is acclaimed that problem solving is the heart of any solid mathematics curriculum (Awofala, 2010) and teachers' perception of the curriculum (Awofala, Ola-Oluwa & Fatade, 2012) should be situated within the need to sustain progressive beliefs that will not impair students' learning of mathematics (Awofala & Awolola, 2011). Hence, students have to master mathematical concepts so that they can calculate satisfactorily and apply them in daily activities.

A number of factors however have been highlighted as being responsible for the poor performance of students in mathematics in Nigeria. Karigi and Tumuti (2015) identified specific variables, such as inadequate teaching and learning materials, lack of motivation and poor attitudes by both the teachers and the students and a psychological fear of the subject. Tukur and Abimbola (2013) also examined the factors affecting the teaching and learning of mathematics in Nigeria and found lack of qualified mathematics teachers, lack of dedication to duty, large class size and lack of mathematics textbooks. Anaduaka and Okafor (2013) opined that Nigerian students' poor achievement in mathematics calls for immediate action so that the country would not be trailing behind others scientifically and technologically for not adequately equipping its citizens with mathematical knowledge and skills. Japan International Cooperation Agency (2012) pointed out the necessity of transforming mathematics lessons from teacher-centred to learner-centred and the need to make mathematics learning more meaningful for the students. In an attempt to adhere to this call, this study examined the effect of lesson study on senior secondary school students' achievement in mathematics.

Lesson study is a systematic investigation of classroom pedagogy conducted collectively by a group of teachers rather than by individuals, with the aim of improving the quality of teaching and learning (Tsui & Law, 2007). Lesson Study is an approach for improving students' learning through collaborative development of lessons and is commonly used by teachers in Japan (Cajkler & Wood, 2013). No wonder that the Japanese students outperformed their counterparts from other countries in Trends in Mathematics and Science Study (TIMSS). According to Lewis (2002), several essential features characterize Japanese lesson study: curriculum goals, lesson development, and reflection. The teachers participating in lesson study begin by purposefully choosing a broad, long-term goal such as for students to learn science with the desire of becoming better problem solvers. Lesson study attends to learning of a particular content area in which students' learning and development is the focus. Lesson study requires repeated teaching and knowledgeable others' involvements (Huang & Han, 2015), and classically includes recurring phases of setting a goal, selecting a topic, planning a research lesson, teaching and observing the research lesson, debriefing, and revising the lesson. During lesson study teachers with a shared focus meet and plan lessons together. These lessons focus on building skills or understanding, and are identified as "research lessons", which are taught by one, and observed by not only all of the teachers who are doing the planning, but also by observers who, at one end of the spectrum, may come only from the teachers' own school, or from other places (Lewis & Tsuchida, 1998). A debriefing session follows the lesson, where the lesson is discussed at some length, with modifications suggested by the observers and an invited academic or "the knowledgeable other". Lesson study has been confirmed to improve students' achievement and narrow achievement gaps (Teele, Maynard, & Marcoulides, 2015) in school subjects including mathematics irrespective of gender.

This study includes gender as a moderator variable because it had been indicated as one of the most important variables in mathematics education (Awofala, 2017). Gender bias is still prevalent in Nigeria and the gender variable has been identified as one of the factors influencing students' achievement in sciences at senior secondary school level (Gambari, Yusuf & Thomas, 2015; Awofala, 2017). Research findings on gender effect in achievement have been inconclusive. For instance, while some researchers have found no significant difference in the academic achievement of male and female students in mathematics (Fatade, Nneji, Awofala & Awofala, 2012; Awofala, 2016, 2017; Awofala & Anyikwa, 2014; Mobark, 2014) others have found a significant effect of gender on students' achievement in mathematics either in favour of males or in favour of females (Khairulanuar, Nazre, Sairabanu & Norasikin, 2010; Mainali, 2014; Awofala, 2011a; Awofala, 2008). These

inconsistent findings have called for the inclusion of gender as one of the moderator variables in this study. The other moderator variable in the study is cognitive style.

Cognitive style is an individual's habitual way of organizing and processing information (Awofala, Balogun & Olagunju, 2011). Shi (2011) defined cognitive style as a psychological construct that is related to how individuals process information. A good number of researches suggest that students with different cognitive styles approach processing of information and problem solving in different ways (Alamolhodaei, 2002). There are a variety of cognitive style measures. Awofala *et al.* (2011) pointed out that there may be different names for the same personality dimension. Four theories of cognitive style were highlighted: Reflection-Impulsivity, Field Dependence-Independence, Holist-Serialist, and Deep-level/Surface-level processing. The personality dimension of interest in this study is the field-dependent/field-independent cognitive style, a widely used dimension of cognitive style in education which specifies an individual's mode of perceiving, thinking, problem-solving and remembering (Witkin & Goodenough, 1981). Witkin and Goodenough (1981) describe the Field Independent (FI) students as those who can easily separate parts from the whole pattern, while Field Dependent (FD) students tend to see things as a whole pattern and find it difficult to separate a whole pattern into parts. Students with FD orientation tend to remember friends or people's face and social aspects such as birth date. FD students like to work in group such as in cooperative learning compared to FI students who like to study independently and are better at manipulating numbers, science facts and problem-solving. Flexibility of thinking was considered as the basis of learning mathematics and science courses by the FI.

Few studies in Nigeria centred on the influence of cognitive style on students' achievement in mathematics. Awofala *et al.* (2011) showed that FI students significantly outscored their FD counterparts in achievement in mathematical word problems. However, MacGregor, Shapiro and Niemiec (1988) found cognitive style to significantly relate to high mathematics achievement in favour of FD students. This inconclusive finding regarding the influence of cognitive style on students' achievement in mathematics warrants further scrutiny. Therefore, this study investigated the effect of lesson study on senior secondary school students' achievement in mathematics. It also examined the moderator effects of cognitive style and gender on senior secondary school students' achievement in mathematics.

## Methodology

The design of the study was the pre-test post-test non-equivalent control group quasi-experimental research design with a  $2 \times 2 \times 2$  factorial representation. The instructional method was manipulated at two levels {lesson study (experimental) and lecture method (control)}, cognitive style at two levels (field dependent and field independent) and gender at two levels (male and female). The design of the study is symbolically given as follows:

|               |                               |                      |
|---------------|-------------------------------|----------------------|
| $O_1 X_1 O_2$ | $X_1 \text{gain} = O_2 - O_1$ | $O_1 O_3$ pre-tests  |
| $O_3 C O_4$   | $C \text{gain} = O_4 - O_3$   | $O_2 O_4$ post-tests |

Where  $X_1$  and C represent lesson study strategy and lecture method respectively. The mean gain scores between  $O_1$  and  $O_2$  and  $O_3$  and  $O_4$  were tested for statistical significance using the Analysis of Covariance (ANCOVA).

The participants comprised 310 Senior Secondary School year two mathematics students (141 males and 169 females) of varied cognitive style (168 field independents and 142 field dependents). Simple random sampling was used to select three intact classes each from

three streams each of two equivalent coeducational senior secondary schools that were distantly located from one another within the city of Lagos, Nigeria. We randomly assigned one school to the lesson study strategy with 156 students (71 males and 85 females) and the remaining one school to the lecture method with 154 students (70 males and 84 females). The mean ages of the students in the lesson study school and lecture method school were 15.4 years ( $SD=3.1$ ) and 15.3 years ( $SD=3.0$ ) respectively.

The instruments used for data collection are Mathematics Achievement Test and Group Embedded Figures Test (GEFT). The Mathematics Achievement Test (MAT) is a collection of questions drawn from past WAEC questions to cover questions on Chord property, Circle theorem, Angles of Elevation & Depression and Bearing. The test was used to quantify students' achievement in mathematics and comprised of two sections namely: objective and theory sections. The objective section was made up of 30 items. Each of these items was followed by four options A-D while the theory section consisted of five questions and this section required students to show their workings in order to reveal their thought processes. Each correct objective question was scored one and a half marks while a theory question solved correctly attracted four marks. This brings the maximum score to 50marks. The test was validated by two senior secondary school mathematics teachers and a mathematics education expert to ensure its face and content validity. For content validity of the MAT, a table of specification prepared in accordance with the Bloom level of cognitive domain was used to ensure coverage of all areas of geometry selected. Using Kuder-Richardson 20, the reliability coefficient of the test was derived as 0.73 by pilot testing the instrument on a sample of 80 students not part of the study sample. The average difficulty index of the MAT was derived as 46% and the average discrimination index of 0.40 was also computed.

The Group Embedded Figures Test is a 25-item standardised instrument developed by Witkin, Oltman, Raskin, and Karp (1971) to classify students into field dependent and field independent cognitive style. Its reliability was reported as 0.82 (Witkin, *et al*, 1971). Aside the general use of GEFT, the choice of this test in this study is predicated on three reasons: First, the GEFT is a non-verbal test which requires only a minimum level of language skill for performing the tasks. Second, the psychometric properties of the test have been evaluated in cross-cultural settings and pronounced quite sound. Third, the GEFT has been adopted and validated for Nigerian use (Awofala, Arigbabu & Awofala, 2013). The test requires students to locate simple geometric figures within more complex geometric designs within a specified time limit. Participants' score on the instrument was used to categorise them into field dependent or field independent cognitive style.

The first section of the test is made up of seven questions and was used as practice. The second and third sections have nine questions respectively and served as the test. The responses are scored as one when students correctly locate the figure and as zero when they can't. Each student's test score was the total number of figures correctly located. Students whose scores fall above the median are regarded as field independent while those whose scores fall on or below the median are regarded as field dependent. The GEFT was revalidated with 80 students through test-retest method leaving an interval of two weeks between the first and second administrations and data collected were correlated using the Pearson Product Moment Correlation and a test-retest reliability coefficient of 0.84 was obtained.

The administration of instrument for the experimental and control groups lasted for six weeks. Week1: Orientation programme for all research assistants and pre-test administration. The Group Embedded Figures Test and Mathematics Achievement Test were administered in the first week. Weeks2–5: These weeks were characterised by the

administration of experimental and control instructional strategies in the schools selected for the study using the instructional procedural steps for experimental and control groups. Week 6: The post-test (MAT) was administered to both the experimental and the control groups.

The Instructional Procedural Steps for Lesson Study in Experimental Group are as follow:

Step 1: The lesson study team members (mathematics teachers) were allowed to set their schedule. They decided when to meet, and distributed the work over a four-week period. Step2: The team members were given the identified areas of students' difficulties which would be covered in the study. The teachers collaboratively designed a lesson plan. Step3: The teachers participated fully in all phases of the lesson study ensuring that each research lesson was a product of the team. Step4: Each week, one of the team members taught the topic to a class while other members of the team served as observers using the 'Lesson study' observation guide. They took down notes on students' responses, reactions, method of solution and necessary areas of improvement. Step 5: The team met after each lesson observation (debriefing session) to incorporate the observations in the new lesson plan called 'the research lesson.' Step 6: The research lessons generated were used to teach the experimental group for the duration of the treatment. Step 7: The instruments were administered on the sixth week and data were analysed.

The Instructional Procedural Steps for Lesson Study in Control Group are as follow:

Step 1: Students were exposed to the lecture method of teaching which involved chalk and talk. Step2: Teacher-centred instruction characterised this stage while students participated passively by taking notes and listening during instruction. The teacher posed problems on the chalkboard and solved them with explanations. In the better part of the instruction time, the students received instruction and engaged in discussions stemming from the teacher's explanations and questions. Step 3: The post-test (MAT) was administered on the sixth week.

Data gathered from the study were analysed using quantitative methods. Statistical tools employed were mean, standard deviation, and Analysis of Covariance (ANCOVA) of the SPSS software. Mean and standard deviation were used to answer research questions while the ANCOVA was used to test the null hypotheses. ANCOVA was employed because pre-test was used as covariates. All hypotheses were tested at 0.05 level of significance.

## Results

**Null Hypothesis One:** There is no significant main effect of treatment on senior secondary school students' achievement in mathematics.

**Table 1: Descriptive Statistics of Achievement gain by Treatment**

| Treatment      | N   | Pre - Test |      | Post -Test |       | Mean Difference |
|----------------|-----|------------|------|------------|-------|-----------------|
|                |     | Mean       | SD   | Mean       | SD    |                 |
| Lecture Method | 154 | 17.45      | 8.12 | 20.05      | 9.61  | 2.60            |
| Lesson Study   | 156 | 15.94      | 6.44 | 41.35      | 13.89 | 25.41           |

Table 1 showed that the experimental group taught mathematics with lesson study had a mean score of 15.94 (SD = 6.44) in the pre-test and a mean score of 41.35 (SD = 13.89) in the post-test making a pre-test, post-test mean difference of 25.41. However, the control group taught mathematics with lecture method had a mean score of 17.45 (SD = 8.12) in the pre-test and a post-test mean of 20.05 (SD = 9.61) with a pre-test, post-test mean difference of 2.60. This showed that students in the experimental group taught mathematics with the lesson study performed better than the students in the control group taught with



the lecture method. Hence, the lesson study strategy was more effective in improving students' achievement in mathematics than then lecture method.

**Table 2: Summary of Analysis of Covariance of Achievement in Mathematics by Treatment, Cognitive Style and Gender**

| Source                           | Type III<br>Sum of<br>Squares | df  | Mean<br>Square | F       | Sig. | Partial Eta<br>Squared |
|----------------------------------|-------------------------------|-----|----------------|---------|------|------------------------|
| Corrected Model                  | 37113.614 <sup>a</sup>        | 8   | 4639.202       | 33.202  | .000 | .469                   |
| Intercept                        | 33062.118                     | 1   | 33062.118      | 236.617 | .000 | .440                   |
| Covariate                        | 763.682                       | 1   | 763.682        | 5.465   | .020 | .018                   |
| Treatment                        | 28820.494                     | 1   | 28820.494      | 206.261 | .000 | .407                   |
| Gender                           | 2.791                         | 1   | 2.791          | .020    | .888 | .000                   |
| CogStyle                         | 322.405                       | 1   | 322.405        | 2.307   | .130 | .008                   |
| Treatment *<br>Gender            | 163.459                       | 1   | 163.459        | 1.170   | .280 | .004                   |
| Treatment *<br>CogStyle          | 109.373                       | 1   | 109.373        | .783    | .377 | .003                   |
| Gender * CogStyle                | 295.697                       | 1   | 295.697        | 2.116   | .147 | .007                   |
| Treatment *<br>Gender * CogStyle | 455.869                       | 1   | 455.869        | 3.263   | .072 | .011                   |
| Error                            | 42058.196                     | 301 | 139.728        |         |      |                        |
| Total                            | 372573.000                    | 310 |                |         |      |                        |
| Corrected Total                  | 79171.810                     | 309 |                |         |      |                        |

a. R Squared = .469 (Adjusted R Squared = .455)

The result in table 2 showed that there was a significant main effect of treatment on senior secondary school students' achievement in mathematics after controlling for the effect of pre- test scores ( $F_{(1, 301)} = 206.261$ ,  $p = 0.000$ ,  $\eta^2_p = 0.407$ ). The partial eta squared ( $\eta^2_p$ ) which is the proportion of the effect + error variance that is attributable to the effect (Awofala, Fatade & Udeani, 2015) was just 0.407 in this study, which means that the factor treatment by itself accounted for only 40.7% of the overall (effect+error) variability in the senior secondary school students' achievement in mathematics score. This result suggested a large effect for treatment. Clearly,  $p < 0.05$  thus, we failed to accept the null hypothesis that there is no significant main effect of treatment on senior secondary school students' achievement in mathematics.

**Null Hypothesis Two:** There is no significant main influence of cognitive style on senior secondary school students' achievement in mathematics.

**Table 3: Descriptive Statistics of Mathematics Achievement by Cognitive Style**

| Cognitive Style | N   | Pre - Test |      | Post -Test |       | Mean Difference |
|-----------------|-----|------------|------|------------|-------|-----------------|
|                 |     | Mean       | SD   | Mean       | SD    |                 |
| FD Independent  | 168 | 17.15      | 7.99 | 31.79      | 15.65 | 14.64           |
| FD Dependent    | 142 | 16.14      | 6.50 | 29.56      | 16.39 | 13.42           |

In Table 3 the field independent students advanced from a pre-test mean score of 17.15 (SD = 7.99) to a post-test mean score of 31.79 (SD = 15.65) which revealed a mean difference of 14.64 while the field dependent students progressed from a pre-test mean score of 16.14 to a post-test mean score of 29.56 and this indicated a mean difference of

13.42. The analyses showed that the field independent cognitive style gained a slightly higher achievement in mathematics than their field independent counterparts. The result in Table 2 above showed that there was no significant main influence of cognitive style on senior secondary school students' achievement in mathematics ( $F_{(1, 301)} = 2.307$ ,  $p = 0.130$ ,  $\eta^2_p = 0.08$ ). Clearly,  $p > 0.05$  hence, we accept the null hypothesis that there is no significant main effect of cognitive style on senior secondary school students' achievement in mathematics.

**Null Hypothesis Three:** There is no significant main effect of gender on senior secondary school students' achievement in mathematics.

**Table 4: Descriptive Statistics of Mathematics Achievement by Gender**

| Gender | N   | Pre - Test |      | Post – Test |       | Mean Difference |
|--------|-----|------------|------|-------------|-------|-----------------|
|        |     | Mean       | SD   | Mean        | SD    |                 |
| Male   | 141 | 16.35      | 6.97 | 31.06       | 15.66 | 14.71           |
| Female | 169 | 16.98      | 7.66 | 30.51       | 16.33 | 13.53           |

Table 4 showed that male students progressed from a pre-test mean score of 16.35 (SD = 6.97) to a post-test mean score of 31.06 (SD = 15.66) with a mean difference of 14.71) while the females progressed from a pre-test mean score of 16.98 (SD = 7.66) to a post-test mean score of 30.51 (SD = 16.33) with a mean difference of 13.53. The mean difference in the achievement of male students was observed to be higher than that of the female students. Thus, there might be slight gender difference in achievement in mathematics in favour of male students in this study. Table 2 revealed that there was no significant effect of gender on students' achievement in mathematics after controlling for the effect of pre-test scores ( $F_{(1, 301)} = 0.02$ ,  $p = 0.888$ ,  $\eta^2_p = 0.000$ ). Clearly,  $p > 0.05$  hence, we accept the null hypothesis that there is no significant main effect of gender on senior secondary school students' achievement in mathematics.

**Null Hypothesis Four:** There is no significant interaction effect of treatment and cognitive style on senior secondary school students' achievement in mathematics.

**Table 5: Descriptive Statistics of Achievement gain by the Interaction of Treatment and Cognitive Style**

| Treatment Style | Cognitive      | N  | Pre-Test |      | Post-Test |       | Mean Difference |
|-----------------|----------------|----|----------|------|-----------|-------|-----------------|
|                 |                |    | Mean     | SD   | Mean      | SD    |                 |
| Lecture         | FD Independent | 83 | 18.22    | 8.82 | 20.84     | 10.00 | 2.62            |
|                 | FD Dependent   | 71 | 16.55    | 7.17 | 19.11     | 9.11  | 2.56            |
| Lesson Study    | FD Independent | 85 | 16.12    | 6.98 | 42.47     | 12.48 | 26.35           |
|                 | FD Dependent   | 71 | 15.73    | 5.77 | 40.00     | 15.39 | 24.27           |

In table 5, the interaction effect of treatment and cognitive style on students' achievement in mathematics can be summarised as follows. In the lesson study group, the field independent students progressed from a pre-test mean score of 16.12 (SD = 6.98) to a post-test mean score of 42.47 (SD = 12.48) with a mean difference of 26.35 while the field dependent students had a mean difference of 24.27 as they progressed from a pre-test mean score of 15.73 (SD = 5.77) to a post-test mean score of 40.00 (SD = 15.39). In the lecture method group, the field independent students progressed from a pre-test mean

score of 18.22 (SD = 8.82) to a post-test mean score of 20.84 (SD = 10.00) with a mean difference of 2.62 while the field dependent students retarded from a pre-test mean score of 16.55 (SD = 7.17) to a post-test mean score of 19.11 (SD = 9.11) with a mean difference of -2.56. Thus, both the field dependent and field independent students gained maximally from the lesson study instruction than their counterparts in the lecture method group. Table 2 showed that there was no significant interaction effect of treatment and cognitive style on senior secondary school students' achievement in mathematics after controlling for the effect of pre-test scores ( $F_{(1,301)} = 0.783$ ,  $p = 0.377$ ,  $\eta^2_p = 0.003$ ). Clearly,  $p > 0.05$  hence, we accept the null hypothesis that there is no significant interaction effect of treatment and cognitive style on senior secondary school students' achievement in mathematics.

**Null Hypothesis Five:** There is no significant interaction effect of treatment and gender on senior secondary school students' achievement in mathematics.

**Table 6: Descriptive Statistics of Achievement gain by Interaction of Treatment and Gender**

| Treatment    | Gender | N  | Pre-Test |      | Post-Test |       | Mean Difference |
|--------------|--------|----|----------|------|-----------|-------|-----------------|
|              |        |    | Mean     | SD   | Mean      | SD    |                 |
| Lecture      | Male   | 70 | 16.34    | 7.16 | 20.66     | 10.68 | 4.32            |
|              | Female | 84 | 18.37    | 8.77 | 19.54     | 8.65  | 1.17            |
| Lesson Study | Male   | 71 | 16.35    | 6.82 | 41.32     | 12.78 | 24.97           |
|              | Female | 85 | 15.60    | 6.12 | 41.36     | 14.83 | 25.76           |

The interaction effect of treatment and gender on achievement is shown in Table 6 which revealed that within the lesson study group, male students progressed from a pre-test mean score of 16.35 (SD = 6.82) to a post-test mean score of 41.32 (SD = 12.78) with a mean difference of 24.97 while the females progressed from a pre-test mean score of 15.60 (SD = 6.12) to a post-test mean score of 41.36 (SD = 14.83) with a mean difference of 25.76. In the lecture method group however, male students progressed from a pre-test mean score of 16.34 (SD = 7.16) to a post-test mean score of 20.66 (SD = 10.68) with a mean difference of 4.32 while the females advanced from a pre-test mean score of 18.37 (SD = 8.77) to a post-test mean score of 19.54 (SD = 8.65) with a mean difference of 1.17. Clearly, both male and female students benefitted maximally from the lesson study instruction than their counterparts in the lecture method group. Table 2 showed that there was no significant interaction effect of treatment and gender on senior secondary school students' achievement in mathematics after controlling for the effect of pre-test scores ( $F_{(1,301)} = 1.170$ ,  $p = 0.280$ ,  $\eta^2_p = 0.004$ ). Clearly,  $p > 0.05$  hence, we accept the null hypothesis that there is no significant interaction effect of treatment and gender on senior secondary school students' achievement in mathematics.

**Null Hypothesis Six:** There is no significant interaction influence of cognitive style and gender on senior secondary school students' achievement in mathematics.



**Table 7: Descriptive Statistics of Mathematics Achievement by the Interaction of Cognitive Style and Gender**

| Cognitive Style | Gender | N   | Pre – Test |      | Post – Test |       | Mean Difference |
|-----------------|--------|-----|------------|------|-------------|-------|-----------------|
|                 |        |     | Mean       | SD   | Mean        | SD    |                 |
| FD              | Male   | 99  | 16.28      | 7.10 | 32.35       | 15.81 | 16.07           |
| Independent     | Female | 69  | 18.41      | 9.02 | 30.97       | 15.50 | 12.56           |
| FD Dependent    | Male   | 42  | 16.50      | 6.73 | 28.02       | 15.05 | 11.52           |
|                 | Female | 100 | 15.99      | 6.42 | 30.20       | 16.95 | 14.21           |

Table 7 showed the descriptive statistics regarding the interaction effect of cognitive style and gender on achievement in mathematics. For the field independent group, male students progressed from a pre-test mean score of 16.28 (SD = 7.10) to a post-test mean score of 32.35 (SD = 15.81) with a mean difference of 16.07, the female students progressed from a pre-test mean score of 18.41 (SD = 9.02) to a post-test mean score of 30.97 (SD = 15.50) with a mean difference of 12.56. In the field dependent group, male students progressed from a pre-test mean score of 16.50 (SD = 6.73) to a post-test mean score of 28.02 (SD = 15.05) with a mean difference of 11.52 while the female students advanced from a pre-test mean score of 15.99 (SD = 6.42) to a post-test mean score of 30.20 (SD = 16.95) with a mean difference of 14.21. This result showed that both male and female students in both field dependent and field independent cognitive style recorded positive improvement in achievement in mathematics in this study.

From Table 2 above, it was observed that there was no statistically significant interaction influence of cognitive style and gender on senior secondary school students' achievement in mathematics ( $F_{(1, 301)} = 2.116$ ,  $p = 0.147$ ,  $\eta^2_p = 0.007$ ). Clearly,  $p > 0.05$  hence, we accept the null hypothesis that there was no statistically significant interaction influence of cognitive style and gender on senior secondary school students' achievement in mathematics.

**Null Hypothesis Seven:** There is no significant interaction effect of treatment, cognitive style and gender on senior secondary school students' achievement in mathematics.

**Table 8: Descriptive Statistics of Achievement gain by the Interaction of Treatment, Cognitive Style and Gender**

| Treatment    | Cognitive Style | Gender | N  | Pre-Test |      | Post-Test |       | Mean Difference |
|--------------|-----------------|--------|----|----------|------|-----------|-------|-----------------|
|              |                 |        |    | Mean     | SD   | Mean      | SD    |                 |
| Lecture      | FI              | Male   | 49 | 16.14    | 7.40 | 20.73     | 10.48 | 4.59            |
|              |                 | Female | 34 | 21.21    | 9.90 | 21.00     | 9.41  | -0.21           |
|              | FD              | Male   | 21 | 16.81    | 6.72 | 20.48     | 11.37 | 3.67            |
|              |                 | Female | 50 | 16.44    | 7.41 | 18.54     | 8.04  | 2.10            |
| Lesson Study | FI              | Male   | 50 | 16.42    | 6.86 | 43.74     | 11.19 | 27.32           |
|              |                 | Female | 35 | 15.69    | 7.21 | 40.66     | 14.10 | 24.97           |
|              | FD              | Male   | 21 | 16.19    | 6.89 | 35.57     | 14.68 | 19.38           |
|              |                 | Female | 50 | 15.54    | 5.30 | 41.86     | 15.44 | 26.32           |

Table 8 showed the descriptive statistics regarding the interaction effect of treatment, cognitive style and gender on students' achievement in mathematics. In the lecture method group, the field independent male students progressed from a pre-test mean score of 16.14 (SD = 7.40) to a post-test mean score of 20.73 (SD = 10.48) with a mean difference of 4.59

while the field independent female students retrogressed from a pre-test mean score of 21.21 (SD = 9.90) to a post-test mean score of 21.00 (9.41) with a mean difference of -0.21. In the lesson study group however, the field independent male students progressed from a pre-test mean score of 16.42 (SD = 6.86) to a post-test mean score of 43.74 (SD = 11.19) with a mean difference of 27.32 while the field independent female students advanced from a pre-test mean score of 15.69 (SD = 7.21) to a post-test mean score of 40.66 (SD = 14.10) with a mean difference of 24.97. For students exposed to the lecture method, field dependent male students advanced from a pre-test mean score of 16.81 (SD = 6.72) to a post-test mean score of 20.48 (SD = 11.37) with a mean difference of 3.67 while the female students in the same group moved from a pre-test mean score of 16.44 (SD = 7.41) to a post-test mean score of 18.54 (SD = 8.04) with a mean difference of 2.10. Among the students exposed to the lesson study treatment, field dependent males advanced from a pre-test mean score of 16.19 (SD = 6.89) to a post-test mean score of 35.57 (SD = 14.68) with a mean difference of 19.38 while the field dependent female students advanced from a pre-test mean score of 15.54 (SD = 5.30) to a post-test mean score of 41.86 (SD = 15.44) with a mean difference of 26.32. These results showed that in the lesson study group, field independent male students reported the highest post-test mean and achievement gain followed by field dependent female students. The field independent females came after while the field dependent males were the lowest in terms of performance within the lesson study group. In the lecture method group, the field independent male students had the highest achievement gain followed by their field dependent male colleagues. This field dependent females come after while the field independent female students recorded a loss in mathematics achievement. The quantified gain in achievement within the control group was observed to be small when compared to the gains observed with the experimental group.

From Table 2 it was observed that there was no statistically significant interaction effect of treatment, cognitive style and gender on senior secondary school students' achievement in mathematics ( $F_{(1, 301)} = 3.263$ ,  $p = 0.072$ ,  $\eta^2_p = 0.011$ ). Clearly,  $p > 0.05$  hence, we accept the null hypothesis that there was no statistically significant interaction effect of treatment, cognitive style and gender on senior secondary school students' achievement in mathematics.

## Discussion

The present study result showed that there was a statistically significant main effect of treatment on senior secondary school students' achievement in mathematics. This finding supported previous findings which associated improved content learning in mathematics to student centred instructional strategies (Awofala, 2010, 2011b, 2011c, 2014, 2016; Akinsola & Awofala, 2008, 2009; Awofala, Fatade & Ola-Oluwa, 2013; Awofala, Fatade & Ola-Oluwa, 2012; Awofala, Arigbabu & Awofala, 2013). The test for the main effect of treatment showed that students exposed to the lesson study performed significantly better than those exposed to the lecture method. Lecture method-a type of traditional instruction- has been found to retard students' achievement in mathematics (Ojaleye & Awofala, 2018). More so in lecture method students are at the mercy of the teachers from whom they remain passive recipient of knowledge without active participation in the construction of knowledge. Lecture method makes teaching effectiveness (Awofala, 2012) impossible and uninteresting to students. The significant effect of lesson study might be because it gave room for teachers to identify students' knowledge gaps in mathematics and remediate these deficiencies during instruction. More so, lesson study has been found to enhance teachers' teaching skills and reflection ability (Huang, Prince, Barlow, & Schmidt, 2017) as feedbacks from knowledgeable others and peers provided them in the present study with ways to analyse

their own thought processes and better reflect on the strengths and weaknesses of the mathematics lesson in order to effectively orchestrate students' thinking.

Result on students' cognitive style revealed that the field dependent students had a slightly higher mean score than the field independent counterparts but this difference in mean score was statistically not significant. Thus, in this study there was no significant main influence of cognitive style on senior secondary school students' achievement in mathematics. This finding agreed with the findings of Idika (2017) who found that field dependent students performed better than field independent students but disagreed with the finding of Arisi (2011) who found that field independent students performed significantly better than field dependent students.

In the present study, male students had a higher achievement mean score than the female students, but the main influence of gender on senior secondary school students' achievement in mathematics was found to be statistically not significant. This result conformed to the findings of researchers (Awofala, 2017; Awofala & Anyikwa, 2014; Fatade, Nneji, Awofala & Awofala, 2012; Awofala, 2016) who believed that gender differences in mathematics achievement are dissipating and are no longer important. However, the results disagreed with the findings of some researchers (Ogunleye, Awofala, & Adekoya, 2014; Awofala, 2008, 2011c) who had found significant influence of gender on students' achievement in mathematics in Nigeria. To them gender differences exist in achievement in mathematics because of differential handling of male and female students in the Nigerian mathematics classroom which often times favours males at the expense of female students.

This study showed that there was no significant interaction effect of treatment and cognitive style on senior secondary school students' achievement in mathematics. This result did not agree with the findings of Agboghroma (2015) whose result indicated a significant interaction effect of treatment and cognitive style on students' achievement. Similarly, in the present study there was no significant interaction effect of treatment and gender on senior secondary school students' achievement in mathematics. This result disagreed with the findings of Dania (2014) who found significant interaction effect of treatment and gender on students' achievement. However, the present finding corroborated the findings of researchers (Awofala & Nneji, 2011; Amosun, 2011; Ogunleye, Awofala & Adekoya, 2014; Ojaleye & Awofala, 2018) who found that there was no significant gender difference in the academic achievement of students when exposed to treatment. In the present study, gender seemed not to interact with instruction to produce results and this means that the treatment conditions did not discriminate across gender in this study.

In addition, the interaction influence of cognitive style and gender on senior secondary school students' achievement in mathematics was not statistically significant. This was in consonance with the finding of Soozandehfar and Souzandehfar (2011) but opposed to the findings of Okoronka and Wada (2014) in which a significant gender and cognitive style interaction was found.

Result on the interaction effect of treatment, cognitive style and gender showed that there was no statistically significant interaction effect of treatment, cognitive style and gender on senior secondary school students' achievement in mathematics. This result agreed with the finding of (Adiatu, 2002) but disagreed with the finding of (Adeyemi, 1987) whose result showed a significant interaction effect of treatment, cognitive style and gender on students' achievement. The insignificant ( $p > .05$ ) 3-way interaction effect indicated that treatment, cognitive style and gender do not mutually influence achievement in mathematics to produce a joint effect. This result can be explained in that achievement in mathematics of

students with different gender and of different cognitive styles may tend to be consistent under any instructional strategy irrespective of whether the students are males or females or whether they are of field independent or field dependent cognitive style.

### Conclusion

Based on the results of this study, it can be concluded that lesson study enhances students' achievement in mathematics better than the lecture method. In the light of the findings of this study, the following recommendations are made: Teachers should use lesson study in developing mathematics lesson plans to enhance students' learning of the subject. Senior secondary school teachers should make effort to study the cognitive style of their students with a view to tailoring their teaching methods in line with the students' cognitive styles. Career counsellors should take advantage of knowledge of students' cognitive styles to guide them on the types of careers in which they are likely to succeed. Educational administrators should incorporate lesson study schedules for mathematics teachers within their work schedules at zonal, state and federal ministry levels. Curriculum experts should organise seminars and workshops at different levels of the education where teachers, textbook authors and other curriculum stakeholders will be enlightened on the effectiveness of lesson study in teaching mathematics so as to ensure optimal achievement of students irrespective of their gender or cognitive style.

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