



## Promoting Interaction Effect of Instructional Model and Gender on Students' Achievement, Interest and Retention in Mathematics

Odo Innocent O.

Department of Science Education, University of Nigeria, Nsukka

### Abstract

This study investigated the interaction effect of First Principles of Instruction and gender on students' achievement, interest and retention in Number and Numeration. The study adopted a quasi-experimental design involving non-equivalent control group design and was conducted in Nsukka education zone of Enugu state, Nigeria. Three specific purposes and three hypotheses guided the study. A purposive sampling technique was used to sample 400 students. The instrument for data collection was Number and Numeration achievement test (NNAT), which was properly validated. Hypotheses were analyzed using the analysis of Covariance at 0.05 level of significance. The result of the study showed that there was no statistically significant interaction effect of instructional model and gender on students' achievement, interest and retention in Number and Numeration. It was recommended that teachers should adopt the strategy in mathematics classroom instruction because, it is gender friendly and does not pose any challenge in streaming of classes based on gender. Government should organize workshops for primary school teachers and secondary school mathematics teachers, through the ministry of education to popularize its use in schools.

**Keywords:** First principles of Instruction Model, Number and Numeration, Achievement, Gender, Interest and Retention

### Introduction

Mathematics is the study of numeracy, measurement, arrangement, shape, change, mensuration, logical reasoning and uncertainties. Mathematics seems to portray life, since one cannot talk about life without mathematics being used, without even realizing it. Hardly does anyone do anything without some elements of mathematics in it, knowingly or unknowingly. For instance, one requires the application of Mathematics in using cell phone, management of money, Sporting activities, banking activities, drug administration, travelling to places, in land, sea and air, playing games, cooking and baking, warfare, computer application, research methodology and analysis (Odo, 2019). As a matter of fact, mathematics cuts across all strata of learning, in arts, humanities, engineering, medicine and social sciences among others. It is therefore important that innovative teaching and learning strategies be applied in mathematics to stem the tide of poor achievements that have been reported over the years (WAEC, 2020; 2021). This is an abysmal failure and is worrisome. The poor achievement of students in mathematics is observed more in Number and Numeration aspect of it.

Number and Numeration is a major component of mathematics curriculum and the first entry point of mathematics for both the primary school pupils and secondary school students. It is one of the broad concepts covered in junior secondary school and continues all through the secondary school. Specifically, Number and

Numeration includes Number systems, fractions/decimals, proportion and approximations in the first three years, followed by logarithm, indices, notation, sequences and series in the last three years. This study was focused on what obtains at the junior secondary school level where poor achievements have been reported. According to West African examination council, WAEC (2020), students avoided questions involving number and numeration, and those who attempted them failed woefully. Studies have shown that instructional process in number and numeration do not engage students in critical thinking, that could help them to integrate (transfer) their knowledge into real-world situation (Agashi, 2014; Obi, 2014; Iyoke, 2015). These researchers have pointed out that the poor achievement of students in this area of mathematics stemmed from the bewildering way mathematics teachers approach teaching and learning processes, employing traditional lecture method without using innovative ideas in mathematics instruction. Although, traditional lecture method is a variable of this study and is still being used in our schools today, its mode of operation may not engage students in the learning process, nor enhance creative thinking by students.

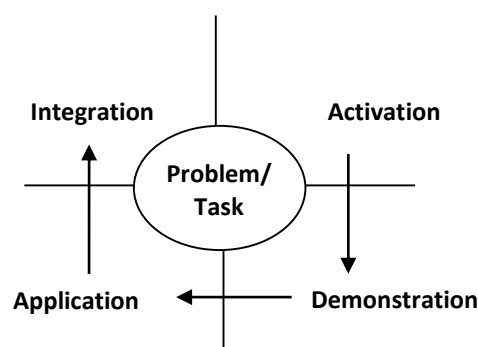
The need to improve the interaction effect of methods and students' achievement in number and numeration through a more efficacious method has increased the awareness of the importance of innovative approaches to instruction. The instructional style should engage the students in

learning using approaches to determine whether interest would be aroused, retention promoted and perhaps, achievement improved upon. This strategy, which First Principles of Instruction seems to provide, can be done though engaging learners in solving real-life problems or tasks that are meaningful to them.

A First principle is the first basis from which a thing is known. In philosophy, a first principle is a basic, foundational proposition or assumptions that cannot be deduced from any other preposition or assumption. In physics, calculation is said to be from First Principles if it starts directly at the level of established laws of physics and does not make assumptions such as empirical model or fitting parameters. In other words a first principle is one that cannot be deduced from any other parameters. First Principles are fundamental concepts or assumption on which a theory, system or method is based (Merrill; 2002). First Principles of Instruction were propounded by Merrill in 2002. According to Merrill (2002), First Principles of Instruction are instructional theories based on a broad review of many instructional models and theories. First Principles of Instruction were created with the goal of establishing a set of principles upon which all Instructional theories and models are in agreement. Merrill, (2002) outlined this set of inter-related principles as: Task/problem-centered, activation, demonstration, application and integration.

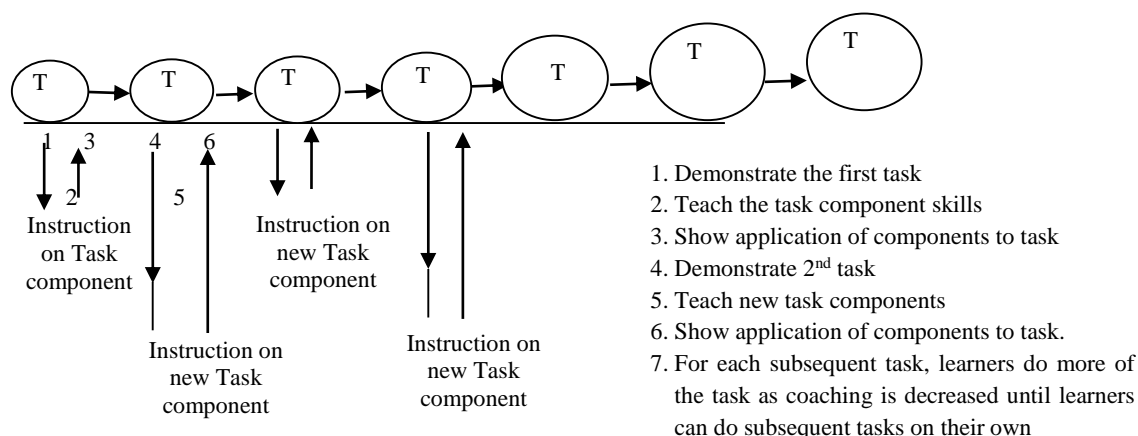
According to Merrill, students can only learn effectively when instruction is anchored on real-life problem that progresses from simple to general or complex. One of the tenets of first principles of instruction is that learning is only meaningful if it can be related to that which the learner already knew. Hence, students' prior knowledge is activated with a view to relating it to

new knowledge during the demonstration phase. In application phase, coaching is provided to help students use their newly acquired skills to complete new tasks. In integration phase, students are encouraged to summarize what they have learnt by way of reflection, discussion or even debate. Based on reflection and discussion, new knowledge or skills learnt could be retained longer and may be used in everyday lives of the students.



**Figure 1: Adapted from Merrill's First Principles of Instruction (2002)**

This figure illustrates the instructional phases that involve the students in four distinct phases of instruction viz: activation of prior experience, demonstration of skills, application of skills and integration of these skills into real-world activities. Much of our instructional practice including traditional lecture method concentrates primarily on phase 2 and ignores the other phases in this cycle of learning. Thus, inability to implement one or more of these principles could undermine effective learning and may lead to low interest and poor retention which may not enhance the achievement of students in Number and Numeration.



**Figure 2: Coaching Procedure and Progression of tasks in Merrill's First Principles of Instruction (2002).**

The figure above shows the instructional technique involved in First Principles of Instruction. The four-phase cycle of instruction is anchored on the fact effective teaching and learning is problem based. Here, the instructional components are taught in a progression of real-life situation where the students are given the problem, shown the components of the problem, taught the component tasks and then shown how the components are used to solve the given problem, which is gradually reduced as students gain expertise. For instance, instruction that teaches fractions should show a demonstration example of equivalent fractions, factors and multiples. These are the component tasks that are necessary to learn fractions, with the next level of instruction presenting tasks that are higher than the proceeding one. This procedure is continued until the students can complete a given task on their own without guidance, in which case the goals of instruction have been attained.

Thus, First Principles of Instructions leads to meaningful learning which sticks and becomes basis for additional information. Meaning learning sustains interest and promotes retention which may lead to high achievement in mathematics.

Interest is very important in learning for it is known that an individual may continue working on something that interests him, even if he is hungry and food is available. Interest, in this context, is the expressed curiosity in or attitude towards mathematics as a subject of study. Research studies have shown inconsistent picture of students' interest in number and numeration (Spelke, 2005; Linn, 2010; Orji, 2013). Employing, innovative instructional delivery like First Principals of Instruction in mathematics classroom is key to retention of learnt material.

Retention is a function of instructional media and motivation. This is because the extent to which learnt material can be remembered is dependent on the nature of instructional approach. Retention is enhanced if the material presented can be related to previous knowledge (Ausubel, 1968). Retention of knowledge remains an inconclusive issue in research. Thus, any instructional strategy which is effective in making students retain mathematical concepts may improve their achievements. The activity oriented nature of first principles of instruction may be a springboard to establish the interaction effect of instructional model and gender on student's achievement, interest and retention.

Gender, in this case, is disparity observable between males and females in terms of power, position or academic achievement. Differential

achievements of students by gender have become an age-long research in education with no definite direction (Agashi, 2014 & Okafor, 2016). These inconsistent picture of achievements among gender, called for further research which explored the interaction effect of First Principle of Instruction and gender on students' achievement, interest and retention in Number and Numeration.

Achievement, in this context, is the cognitive achievement of students in terms of passes in Mathematics tests administered by teachers or public examination administered by WAEC or NECO upon application of First Principles of Instruction. Poor achievements continue to reverberate (WAEC, 2020; NECO, 2021), despite the use of several models to improve their interaction effects on students' achievement, interest and retention, Ogbu (2020), A change in instructional model like First Principles of Instruction was therefore advocated. When used as media of instruction in other subject areas, (Odupe & Opeisa, 2019 & Ogbu, 2020), First Principles of Instruction proved to be effective in improving achievement. In these studies, none investigated the interaction effect of models and gender on students' achievement, interest and retention. But, a study by Nwaodo (2016), on the relative effectiveness of Reda and Rusbuit's problem solving models on metal work, found significant interaction effect on instructional model and gender on students' achievement, interest and retention. But, another study by Obi (2014), on the use of Origami as instructional model found no significant interaction effect on this model and gender on students' achievement and interest but found interaction effect of model and gender on students' achievement and retention. Interestingly, these findings have left room for further research on this issue. Hence, the interaction effect of First Principles of Instruction and gender on students' achievement, interest and retention was investigated in this study.

### Statement of the Problem

There are evidences of students' poor achievement in mathematics going by the revelation of examining bodies in Nigeria like West African Examination Council and National Examination Council. Efforts aimed at improving the achievement of students through some teaching models have not yielded the desired results especially with respect to gender. Literature has revealed that any model that is activity-oriented could promote interaction effect with respect to gender on students' achievement, interest and retention. A model like First Principles of Instruction, where prior knowledge is activated

and it becomes basis for the reception of new knowledge, which is properly demonstrated and then students apply the newly acquired knowledge and integrate them into their lives for meaningful learning to occur, could be one of the ways forward. Thus, the interaction effect of First Principles of Instruction and gender on students' achievement, interest and retention was investigated in this study.

### **Purpose of the study**

The general purpose of the study was to investigate the interaction effect of First Principles of Instruction and gender on students' achievement, interest and retention in Number and Numeration. Specifically this study sought to find the:

1. Interaction effect of Instructional model and gender on students' achievement in Number and Numeration.
2. Interaction effect of Instructional model and gender on students' interest in Number and Numeration.
3. Interaction effect of Instructional model and gender on students' retention in Number and Numeration.

### **Hypotheses**

The following null hypotheses were formulated to guide the study and were tested at 0.05 level of significance.

1. There is no significant interaction effect of gender and instructional model on students' achievement in Number and Numeration.
2. There is no significant interaction effect of instructional model and gender on students' interest in Number and Numeration.
3. There is no significant interaction effect of gender and instructional model on students' retention in Number and Numeration.

### **Methods**

The study adopted a quasi-experimental research design involving non-equivalent control group design. The design was considered

appropriate because intact classes were used as a group in each school. The study was conducted in Nsukka education zone of Enugu state, Nigeria, made up of five local government areas. The population of the study was 4,489 junior secondary school one students. Multi stage sampling procedure was used to collect data. First, simple random sampling technique by balloting was used to select two out of five local government areas in Nsukka education zone. Purposive sampling was used to select two schools from each of the local government areas based on gender. The sample of the study was 400 students, made up of 188 males and 212 females from four intact classes.

The instrument for data collection were Number and Numeration Achievement Test (NNAT), Number and Numeration Interest Test (NNIT) and Number and Numeration Retention Test (NNRT), made up of 8 essay and 30-multiple choice questions developed by the researchers using Test Blue Print to ensure content validity. The instrument was properly validated. The instrument was trial-tested on 30 students from a co-educational school in another education zone of the state. The test-retest stability measure of the essay and multiple choice tests were 0.99 and 0.79 respectively, using Pearson  $r$ , while the internal consistency of the multiple choice test was 0.97, using Kuder-Richardson 20 (KR-20) formula. The inter-rater reliability of the essay test was 0.94, using Kendall coefficient of concordance. Six research assistants were trained on the conduct of this study, using manual on Merrill's First Principles of Instruction. The data obtained from the study were analyzed using mean and standard deviation to answer research questions while hypotheses were tested at 0.05 level of significance using the analysis of Covariance (ANCOVA)

### **Results**

The results are presented in tables according to the hypotheses that guided the study.





**Table 1: Analysis of Covariance (ANCOVA) on interaction effect of First Principle of Instruction and Gender on students' Achievement in Number and Numeration when taught with First Principles of Instruction (FPI).**

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	20888.103	4	5222.026	164.630	.000
Intercept	12758.892	1	12758.892	402.239	.000
PretestAchi	7128.291	1	7128.291	224.728	.000
Methods	11952.603	1	11952.603	376.820	.000
Gender	233.700	1	233.700	7.368	.072
Methods * Gender	70.101	1	70.101	2.210	.138
Error	12529.274	395	31.720		
Total	1305463.000	400			
Corrected Total	33417.377	399			

a. R Squared = .625 (Adjusted R Squared = .621)

The result in Table 1 indicates that an F-ratio of 2.210 with associated probability value of 0.138 was due to the interaction effect of instructional methods and gender on students' achievement in Number and Numeration. Since the associated probability (0.138) was greater than 0.05 set as the benchmark for taking a decision, the null hypothesis which stated that;

there is no significant interaction effect of instructional method and gender on students' achievement in Number and Numeration was upheld. Therefore, inference drawn was that there was no significant interaction effect of instructional method and gender on students' achievement in Number and Numeration.

**Table 2: Analysis of Covariance (ANCOVA) on interaction effect of First Principle of Instruction and Gender on students' Interest in Number and Numeration when taught with First Principles of Instruction (FPI).**

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	13534.267 <sup>a</sup>	4	3383.567	129.379	.000
Intercept	11630.378	1	11630.378	444.715	.000
PretestInt	384.947	1	384.947	14.719	.000
Methods	12529.820	1	12529.820	479.107	.000
Gender	257.267	1	257.267	9.837	.002
Methods * Gender	163.365	1	163.365	6.247	.053
Error	10330.210	395	26.152		
Total	1163741.000	400			
Corrected Total	23864.478	399			

a. R Squared = .567 (Adjusted R Squared = .563)

The result in Table 2 shows that an F-ratio of 6.247 with associated probability value of 0.053 was due to the interaction effect of instructional method and gender on students' interest in Number and Numeration. Since the associated probability (0.053) was greater than 0.05 set as the benchmark for taking a decision, the null hypothesis which stated that;

there is no significant interaction effect of instructional method and gender on students' interest in Number and Numeration was not rejected. Therefore, inference drawn was that there was no significant interaction effect of instructional method and gender on students' interest in Number and Numeration.



**Table 3: Analysis of Covariance (ANCOVA) on interaction effect of First Principle of Instruction and Gender on students' Retention in Number and Numeration when taught with First Principles of Instruction (FPI).**

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	33714.565 <sup>a</sup>	4	8428.641	615.287	.000
Intercept	1810.263	1	1810.263	132.148	.000
PosttestAchi	10883.701	1	10883.701	794.505	.000
Methods	2359.159	1	2359.159	172.217	.000
Gender	53.828	1	53.828	3.929	.048
Methods * Gender	4.331	1	4.331	.316	.574
Error	5410.995	395	13.699		
Total	1446196.000	400			
Corrected Total	39125.560	399			

a. R Squared = .862 (Adjusted R Squared = .860)

The result in Table 3 shows that an F-ratio of 0.316 with associated probability value of 0.574 was due to the interaction effect of instructional method and gender on students' retention in Number and Numeration. Since the associated probability (0.574) was greater than 0.05 set as the criterion for taking a decision, the null hypothesis which stated that; there is no significant interaction effect of instructional method and gender on students' retention in Number and Numeration was not rejected. Hence, inference drawn was that there was no significant interaction effect of instructional method and gender on students' retention in Number and Numeration.

### Interaction Effect of Instructional Method and Gender on Students' Achievement, Interest and Retention in Number and Numeration

The result which indicates an F-ratio of 2.210 with associated probability value of 0.138 was due to the interaction effect of instructional method and gender on students' achievement in Number and Numeration. It is evident that the interaction effect of instructional method and gender is not significant on students' achievement. This is an indication that gender is not a factor to reckon with in the choice of instructional technique for enhanced achievement of students in Number and numeration. The finding is in agreement with Orji (2013) and Obi (2014) who found similar results in their separate studies.

On the other hand, the result which shows an F-ratio of 6.247 with associated probability value of 0.053 was due to the interaction effect of instructional method and gender on students' interest in Number and Numeration. The interaction effect was not statistically significant meaning that both male and female students improved on their interest greatly after the experiment. The result indicates that

the study generates and sustains the interest of male and female students equally thereby encouraging gender equality in the teaching and learning of mathematics especially in number and numeration. This finding shows that the instructional method enhanced interest and encouraged retention, which in turn aided achievement. This finding agrees with the findings of Obi (2014) and Nwaodo (2016) who reported similar results in their separates studies.

Similarly, an F-ratio of 0.316 with associated probability value of 0.574 was due to the interaction effect of instructional method and gender on students' retention in Number and Numeration. It is evident that the interaction effect of instructional method and gender was not significant for retention of knowledge in Number and Numeration. This result indicates that for enhanced retention of knowledge in Number and Numeration, gender is not a factor to reckon with in the choice of instructional strategy. In other words, this study is gender friendly in terms of retention of knowledge. This finding agrees with Agashi (2014) and Nwaodo (2016) who had earlier reported similar findings in their separate studies.

### Conclusion

Based on the result obtained, the following conclusions can be deduced. There was no significant interaction effect of instructional method and gender on students' achievement, interest and retention in Number and Numeration. Hence, to promote interaction effect of instructional model and gender on students' achievement, interest and retention in mathematics, First Principles of Instruction becomes Imperative.

### Educational Implications of the Study

The findings that there was no significant interaction effect of instructional model and gender on students' interest, achievement and retention shows that gender is not a factor to be considered in the choice of instructional strategy, implying that the method is gender friendly not-only in terms of interest but also in terms of achievement retention of knowledge.

### Recommendations

Students should employ First Principles of Instruction in solving problems in Number and Numeration since the method is gender friendly in terms of achievement, interest and retention. It is therefore so recommended for use in the school since it does not pose any challenge in streaming of classes based on gender.

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