Effects of Gagne's Learning Hierarchy on Students' Academic Achievement and Retention in Mathematics, among Senior Secondary Schools in Kano Metropolis, Kano State, Nigeria

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ABSTRACT: The study investigated the Effects of Gagne's Learning Hierarchy on Students' Academic Achievement and Retention in Mathematics, among Senior Secondary Schools in Kano Metropolis, Kano State, Nigeria. The study was guided by four objectives and four hypotheses respectively. The design was quasi-experimental, non-equivalent pre-test, post-test and post-post test. The population of the study was eight (8) public schools. The sample size was one intact class selected each of the four selected schools using both stratified and random sampling techniques. Two classes were assigned as experimental while other two were assigned as control classes. The validated instrument for data collection was a Mathematics Achievement Test (MAT) with 25items of multiple choices with 4 options (A-D). The experiments were taught using Gagne's learning hierarchy while the controls were taught the same topics using conventional teaching method for six (6) weeks. The collected data were analyzed using inferential statistics (Z-test of independent sample) to test the hypotheses. The result of the findings in hypothesis, one revealed that, Gagne's learning Hierarchy has a significant effect on students' academic achievement in Mathematics,the post-test result showed that $(Z = 13.36; p = 0.00 < 0.05; df = 276)$.While hypothesis two results revealed that, there was no difference based on genderon the achievement in Mathematics $(Z = 0.488; p=0.427>0.05; df= 143)$. The hypotheses three and four results revealed that, there was significant difference on Students' level of Retention in Mathematics between the experimental and the control groups $(Z = 12.82; p=0.000<0.05; df= 276)$. AS well as based on Gender when exposed to Gagne's Learning Hierarchy $(Z=-5.457; p=0.000<0.05; df= 143)$ respectively.The study concludes that, using Gagne's Learning Hierarchy in teaching Mathematics improves students' academic achievement and retention in mathematics and also recommends that, School management should encourage their teachers to use Gagne's Learning Hierarchy in teaching Mathematics taking into consideration the gender gaps in the subject (mathematics).

I. INTRODUCTION

Mathematics is one of the important science subjects taught at any level of Education, is also one of the core subjects that students are required to pass at credit level in order to qualify for admission into any of the tertiary institutions for further studies (Aduda, 2003). Despite the Central role plays in society and important position the subject has in sciences and science-related disciplines in Nigeria, research findings revealed that, there has always been poor performance, low academic achievement in the subject (Mathematics) by Students at Secondary School Certificate Examinations (SSCE) consistently and unimpressive (Njoku, 2005). Many factors have been suggested as contributing to this poor performance and low academic achievement of students in Mathematics in general. Some of these factors include: School based factors, such as; inadequate infrastructure and equipment, poor teaching methods, lack of adequate qualified Mathematics Teachers, parental Socio Economic factors, Students' psychosocial factors (Bankole, 2001).

In promoting greater achievement and performance, some findings reported that, teachers must select the kind of teaching Strategy that can foster greater retention of learning, which means of delayed achievement tests (Sousa, 2006). For example, Sousa (2006) reports the average percentage of learning material retention after 24 hours when students were taught by different

teaching methods. He indicates that there is retention of 50% of material learned in the discussion group, 75% as a result of requests for students to study through practice, and 90% when students teach others. In addition, Moore (2008) reports studies showing that a blend of 'telling' and 'showing' techniques results in greater retention (65%) after three days. It is therefore argued that the best way to learn something effectively is to prepare to teach it.

There were many instructional strategies that have been advocated by curriculum designers and science educators to help and improve on the failure rate among secondary school science students; Examples of these strategies include guided discovery approach, demonstration method, discussion method, problem-solving and so on for teaching senior secondary school (Eniayeju, 2001). Research findings had, however revealed that, to date, a large proportion of science teachers, still choice to the use of traditional/lecture method rather than the activity-oriented strategies advocated for, such as demonstration method problem-solving and others (Olorukooba, 2001).

For the purpose of this study, Students' Academic Achievement and Retention in Mathematics, among Senior Secondary Schools, based on Gagne's theory of learning hierarchy of teaching and learning science subjects has been considered as relevant and fruitful. Gagne's theory of the learning hierarchy has advocated for the hierarchical structure where learners are exposed to different concepts from simple to complex concepts. In this study, therefore, the effects of Gagne's learning hierarchy on Students' Academic Achievement and Retention in Mathematics, among Senior Secondary Schools Students in Maiduguri, would be investigated.

According to Kearsley (1994), Robert Gagne's theory of learning is often referred to as Gagne's theory of learning hierarchy has a new concept or skill depends upon the mastery of pre-requisite concepts which are hierarchically arranged. This implies that prior knowledge determines what further learning may take place, which also implies that materials meant for learning must be sequentially structured by the teacher. The importance of theory in the teaching of Mathematics is that, it will allow students to achieve meaningful learning through the movement from previous learnt concepts to abstract concept. For instance before the Senior Secondary School students comprehend any concepts of Mathematics, they must be familiar with lower

concepts/prerequisite to the new topic.And the arrangement of the simple learning task (prerequisite) to complex task (new knowledge), is what is called learning hierarchy according to Gagne's theory of learning. It is based on this learning theory, (i.e. Intellectual skills development) which was organized in a hierarchy according to complexity by Gagne that this study was based. This learning hierarchy therefore served as a guide in teaching any topic in Mathematics, with the hope of enhancing Students' academic achievement and level of Retention in the topic (Kearsley, 1999).

According to Nwachukwu, (2008), Science, Mathematics inclusive as an important subject required for sustainable development and nation building, should be taught using effective instructional approach capable of seeking for, maintaining high achievement and retention among students irrespective of gender. These two terms are closely related,that is achievement is retention, because a knowledge retain can be recalled when needed (Okeke, 2008).Retention is a process of transferring information from short memory to long term memory. Information that is interesting will be retained when it has reached the long term memory. Retention comes in before recall. It is recall that reveals how much the students have retained during teaching and learning. Long term memory is associated with the brain hemispheres(Okeke, 2008).

II. STATEMENT OF THE PROBLEM

Poor students' academic achievement and retention in Mathematics is alarming, despite the huge investment in education, the performance of the students in senior secondary school certificate examinations (SSCE) has long been in recordand became the matter of concern to many well-meaning individuals, institutions and organizations as well as various levels of governments (Kpolovie, Ololube, &Ekwebelem, 2011).

The low Students' academic achievement in mathematics has become a concern in mathematics education (Kajuru&Kauru, 2010). Yet many students find it very difficult to solve mathematical problems. The reason for these difficulties may vary but this could sometimes be related to the teaching methods being used to explain such topics (Chianson, Kurumeh&Obida, 2010).

Many reasons have been advanced for this poor state of students' academic achievement in mathematics. Some researchers viewed strategy of

teaching as one of the contributing factors to poor performance of students in mathematics (Chiansonet al, 2010). For these reasons, many instructional approaches have been tendered by Psychologist like Bruner, Piaget, Gagne, to improved academic achievement, retention as well as interest in Mathematics and other science subject, but the bad situation been in record Amaefula (2004).

Njoku (2009) strongly believed that the instructional approach adopted by Mathematics teacher in teaching Mathematics is to a large extend responsible for the observed consistent poor achievement and retention in Mathematics and other Science related subjects. Also the West African Examination Council (WAEC) Chief Examiners Report for Kano State, 2014, 2015, 2016, 2017, and 2018, reported students' general poor performance in Mathematics, as in Table 1.

Table 1: Students' Academic Achievement in Mathematics at (SSCE) level in West African Examination Council (WAEC) in Kano Metropolis, Kano State from 2014-2018

Years	Registered students	No of Passed Students	% of passed Students	No of Failed Students	% of failed Students
2014	10557	4386	41.5	6171	58.5
2015	11592	3996	34.5	7596	65.5
2016	10612	5031	47.4	5581	52.6
2017	10536	4791	45.5	5745	54.5
2018	15345	7941	51.7	7404	48.3

Source: Kano State, Education Resource Centre (KSERC), 2019

Objectivesof the Study
The Objectives of the Study are:
1) To determine the effects of Gagne's Learning Hierarchy on Students' Academic Achievement in Mathematics, among Senior Secondary Schools in Maiduguri.
2) To find out the effects of Gagne's Learning Hierarchy on Students' Academic Achievement in Mathematics, based on Gender among Senior Secondary Schools in Maiduguri.
3) To investigate the effects of Gagne's Learning Hierarchy on Students' level of Retention in Mathematics, among Senior Secondary Schools in Maiduguri.
4) To examine the effects of Gagne's Learning Hierarchy on Students' level of Retention in Mathematics, based on Gender among Senior Secondary Schools in Maiduguri.

Research Hypotheses of the Study
To achieve the objectives of the Study, following null hypotheses were formulated and tested at0.05 level of significance
H_{01}: There is no significant difference on the effects of Gagne's Learning Hierarchy on Students' Academic Achievement in Mathematics, among Senior Secondary Schools in Maiduguri.
H_{02}: There is no significance difference on the effects of Gagne's Learning Hierarchy on Students' Academic Achievement in Mathematics, based on

Gender among Senior Secondary Schools in Maiduguri.
H_{03}: There is no significance difference on the effects of Gagne's Learning Hierarchy on Students' level of Retention in Mathematics, among Senior Secondary Schools in Maiduguri.
H_{04}: There is no significance difference on the effects of Gagne's Learning Hierarchy on Students' level of Retention in Mathematics, based on Gender among Senior Secondary Schools in Maiduguri.

Review of related literature
Yusuf (2013) conducted a research study on the Effects of Using Gagne's Learning Hierarchy on Chemistry Students' Academic Achievement and Anxiety level in Balancing Chemical Equations in Secondary Schools in Katsina, Nigeria. The population of this study comprised ten (10) Public Senior Secondary Schools consists of single sex and co-educational schools; there are two (2) male schools, two (2) female schools and six (6) co-educational schools. TheSimple random sampling technique was used to select two Senior Secondary Schools out the population. The selected schools were (1) Government Senior Secondary School Kofar Yandaka, (2) Government Senior Secondary School KofarKaura, with the sample size of 100 SSII students. The two schools were placed as experimental and control groups each with 50

students. A quasi-experimental pretest-posttest research design was used for the study. The study subjects in the experimental group were taught using Gagne's learning hierarchy, while the control group was taught using lecture method for the period of six weeks. Two instruments; Balancing Chemical Equation Achievement Test (BCEAT), and Students' Anxiety Scale Questionnaire (SASQ) with reliability coefficient of 0.79 and 0.78 respectively, were used to collect data for the study. Performances of the two groups were compared using their posttest mean scores. The major findings from the study are: Students taught using Gagne's learning hierarchy recorded high academic achievement than those taught using to lecture method. The finding recommends that, Chemistry teachers should as much as possible arranges concepts taught in Chemistry hierarchically so that students can learn the simple concepts which will help their understanding of abstract or complex concepts.

Sreelakshmi, McLain, Jayakrishnan, Rajeshwaran, Rao, &Bijlani, (2015) conducted a study on the Gamification to Enhance Learning Using Gagne's Learning Model in India. The general aimed of the study was to explored on a novel way to improve how high school students learn by building a serious game that uses a pedagogical model developed by Robert Gagne. By integrating serious game with principles of Gagne's learning model can provide engaging and meaningful instructions to students. The game developed in this study is a waste sorting game that can easily and succinctly demonstrate the principles of this learning model. All the tasks in the game that the player has to accomplish correspond to Gagne's "Nine Events of Learning". A quiz is incorporated in order to get data on the progress made by the player in understanding the concept and as well as to assess them. Additionally, an experimental study was conducted which demonstrates that game based learning using Gagne's event is more effective than a traditional classroom setup.

III. MATERIALS AND METHODS

The design for this study was quasi experimental design adopted Pretest, post-test and post-posttest. The reasons for using quasi experimental design; it involves selecting of groups that is intact class as experimental and control groups, upon which variableswere tested (Shuttleworth, 2008). To avoid distraction of normal classroom activities, because, sometimes it is possible that school system may not accept new programs for testing on an experimental basis, may not allow intact classes to be disrupted or divided to provide for random or equivalent samples, may not allow for a treatment to be given to some and withheld from others (Isah, 2015). In quasi-experiment, there must be two groups that is experimental and control groups, each one will be tested through Pretest, post-test and post-posttest. A pretest was administered from the beginning to determine the equivalence in ability of the two groups whereas, posttest was also administered to the both groups of the students after six (6) weeks of treatments to evaluate the effectiveness of the treatment in improving Students' achievement and retention in Mathematics. After the Pre-test, the experimental groups were exposed to Gagne's Learning Hierarchy while control groups were taught with conventional method, both for six consecutive weeks. Two weeks after the post-test, post-posttest was administered to the both groups in order to test the level of their retention. The instrument used wasMathematics Achievement Test (MAT) for pre-test, post-test and post-posttest.

The population for this study comprised of eight (8) public senior secondary schools in Kano Metropolis, Kano State, which includes; two (2) male schools, two (2) female schools and four (4) mixed (coeducation) schools. The total population is twenty three thousand five hundred and seventeen **(23,517)**, which consist of thirteen thousand seven hundred and eight **(13,708)** males and nine thousand eight hundred and nine **(9,809)** female. The average age of the population will be seventeen (17) years old, which are SS2 students. The summary of the population for this study is shown in the table 1.2 below.

<div align="center">**Table 2: Table of Population of students**</div>

S/N	Name of Schools	Number of Male students	Number of female students	Total
1	A	5086	------	5086
2	B	1600	------	1600
3	C	------	2084	2084
4	D	------	3225	3225
5	E	1710	1203	2913
6	F	1528	967	2495
7	G	2268	981	3249
8	H	1516	1349	2865
	TOTAL	**13,708**	**9,809**	**23517**

Sources: Kano State Ministry of Education (KSMOE), 2019

The sample size of this study were four (4) selected schools which are; A, B, C, and D, with four (4) intact classes of SS II (one from each school) were selected. The selected male and female schools each have (one experimental and one control school). All the students of each intact class despite their ability levels were used as sample for the study.

Stratified random sampling technique was used to select a sample of four (4) schools out of the eight (8) Senior Secondary Schools in Kano Metropolis, Kano State. The use of stratified random sampling method according to Cohen, Manion and Marrison (2007) stratified random sampling involves dividing the population into homogeneous groups, each group containing subjects with similar characteristics. The sample schools were stratified male schools and female schools. In each of the two (2) stratums (male and female schools), all thetwo schools were selected. Furthermore, one intact class from each of the four (4) schools was selected to have total of four (4) classes as samples, in each of the two (2) male and female schools one class was assigned as experimental class while other class as control. Those in the experimental class were taught Mathematics usingGagne's learning hierarchy while those in the control class were taught the same topics using conventional teaching method for six (6) weeks.

The instruments for this study were Mathematics Achievement Test (MAT), which consists of two (2) sections (section A and section B). In section A, general information about the student and school were required, such as; type of school and gender. Its section B contains of twenty five (25) items of multiple choice objective tests. The items were drawn carefully within the scope of Mathematics SSII syllabus. The students required to select the correct answer from the four options lettered A-D.

The content validation of the Mathematics Achievement Test (MAT) for this study was carried out by a panel of experts comprising of two senior lecturers from Bayero University Kano (BUK) and a mathematics teacher with B. Sc. Ed. (mathematics), 25years teaching experience in Kano Metropolis Secondary School, Kano State. In addition has experience in both WAEC and NECO Exams.They made suggestions and corrections with respect to the following criteria: the appropriateness of the items, whether or not the statements in the tests were clear, readable, hard or too simple for SS II students, whether or not the test items are related within the contain of the Senior Secondary School Mathematics syllabus. Their suggestions and corrections were taken into consideration in the final formulation of the test instruments before administration.

The instrument was pilot tested in one of the coeducation, which is School (G) with 40 respondents (20male and 20female) in order to determine thefeasibility and reliability co-efficient of the instrument adapted. The reliability of the instruments was obtained through Cronbach Alpha (Kuder-Richardson formula (KR-20)method, which is 0.78.

The researcher collected an introductory letter from the Department of Science and Technology Education (STE), Bayero University Kano and toke it to the Director of Schools, Kano State Ministry of Education, to obtain the necessary approval to conduct the study with directives of the Director of Schools, Kano State Ministry of Education, to the principals of the sample schools to seek for their permission to carry out field study in their respective schools, the principals introduced the researcher to the Mathematics

teachers and then, the teachers introduced Him to the students. The researcher has engaged four (4) research assistants, one from each school and specifically mathematics oriented teachers with a minimum of B. Sc. (Ed) qualification and above with not less than five years of teaching experience.The research assistants were trained for the need to maintain professionalism throughout the treatment phases. Pre-test was administered to both groups before treatment, Post-test was administered to the students after completion of six (6) weeks of teaching sessions (treatment) and Post-posttest later followed after two weeks of the post-test to measure the students' academicachievements, level Retention and the effectiveness of the Gagne's learning hierarchy in teaching Mathematics.

The data collected were analyzed using inferential statistics (independent sample Z-test) to test the hypotheses at $\alpha = 0.05$ level of significance. Statistical Package for Social Sciences (SPSS) version 16.0 was used for data analysis.

IV. RESULTS

The summary of the data on the number of students sampled from each school under study base on the gender of the respondents were presented in tabular form and charts.

distribution of the respondents based on schools

SCHOOLS	FREQUENCY	PERCENTAGES
School A	75	26.98%
SchoolB	68	24.46%
SchoolC	70	25.18%
SchoolD	65	23.38%
TOTAL	**278**	**100%**
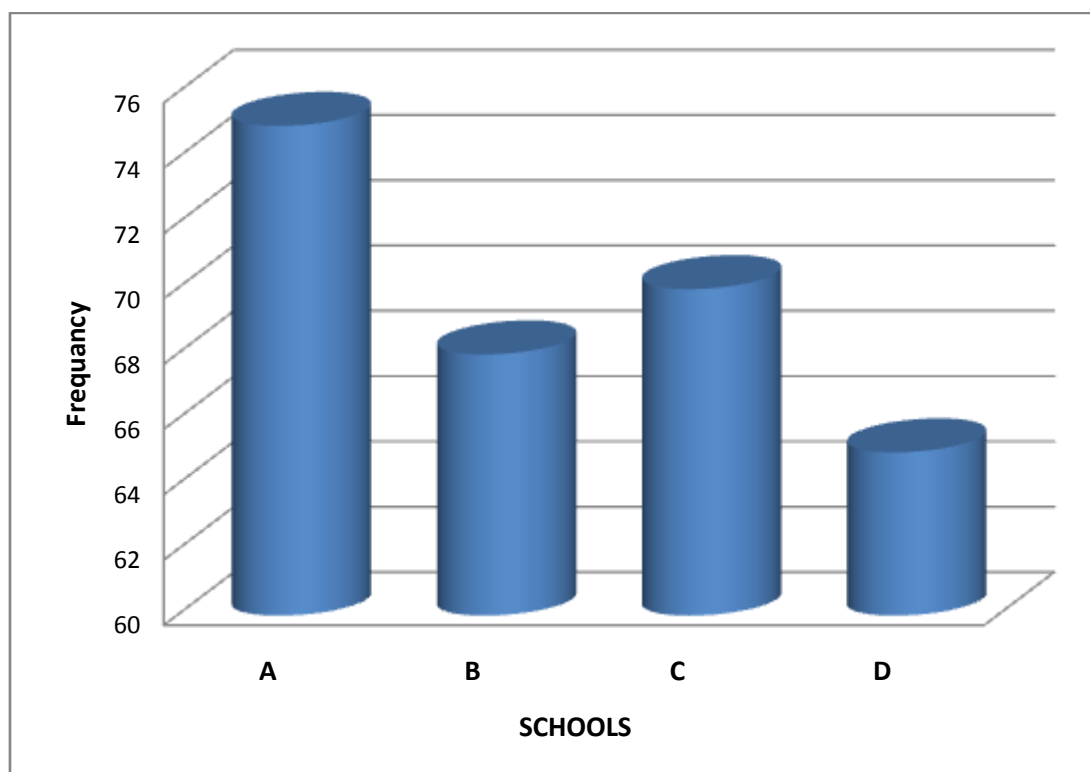
Bar-chart showing the distribution of students of the sampled schools

The Bar Chart had shown the distribution of the sampled schools and number of Students from each school. Where 52 respondents representing 26.98% were from school A, 68 respondents representing 24.46% were from school B, 70 respondents representing 25.18% were from school C while 65 respondents representing 23.38% of the respondents were from school D. Therefore, school A has the highest number of respondents while school D has the lowest number of respondents.

Hypothesis One: There is no significant difference on the effects of Gagne's Learning Hierarchy on Students' Academic Achievement in Mathematics, among Senior Secondary Schools in Kano

The Mathematics Achievement Test (MAT) was used in collecting the data on the effects of Gagne's Learning Hierarchy on Students' Academic Achievement in Mathematics, among Senior Secondary Schools in Kano and the summary of the analyses are presented in Table 1.8, using frequency (N), Mean ($\bar{x}$), Standard Deviation (SD) and Z - test.

Table 4: Summary of the post-test results of the independent sample z-test on the effectiveness of students' academic achievementin Mathematics when expose toGagne's Learning Hierarchy

Group	POST – TEST					
	N	$\bar{x}$	SD	Df	Z	P-value
EXP.	145	32.80	2.49			
				276	13.36	0.000
CON.	133	26.46	4.92			
TOTAL	278					

Results from Table 4 of the post-test revealed that, there was significant difference between the experimental and the control groups with p-value 0.00 which is less than the level of significant (α=0.05), the mean score (32.80) of the experimental group is higher than the mean score (26.46) of the control group with the difference of 6.34. Therefore, Gagne's learning Hierarchy has significant effect on students' academic achievement in Mathematics, as such, hypothesis one is rejected. And Gagne's Learning Hierarchy is effective in teaching Mathematics than Conventional method.

Hypothesis Two: There is no significance difference on the effects of Gagne's Learning Hierarchy on Students' Academic Achievement in Mathematics, based on Gender among Senior Secondary Schools in Kano.

The Mathematics Achievement Test (MAT) was used to collect data on the effects of Gagne's Learning Hierarchy on Students' Academic Achievement in Mathematics, based on Gender among Senior Secondary Schools in Kano and the summary of the analysis is presented in table 5, using frequency (N), Mean ($\bar{x}$), Standard Deviation (SD) and Z - test.

Table 5: Summary of the post-test results of the independent sample z-test on the effectiveness of students' academic achievementin Mathematics, based on Gender among Senior Secondary Schools in Kano, when expose toGagne's Learning Hierarchy.

Group	POST – TEST					
	N	$\bar{x}$	SD	Df	Z	P-value
MALE	75	30.89	4.42			
				143	0.488	0.427
FEMALE	70	31.21	4.32			
TOTAL	145					

Result from Table 4 showed that, there was no significant difference on students' academic achievement in Mathematics, based on Gender among Senior Secondary Schools in Kano, when expose to Gagne's Learning Hierarchy, because the p-value (0.427) is greater than the level of significance (α=0.05). Therefore, hypothesis two

was accepted. The results further revealed that, the mean score of the male students (30.89) and the mean score of the female students (31.21) are almost the same, because the difference is statistically not significant. This shows that there was no difference in the achievement of boys and

girls when exposed Mathematics using the Gagne's Learning Hierarchy.

Hypothesis Three: there is no significance difference on the effects of Gagne's Learning Hierarchy on Students' level of Retention in Mathematics, among Senior Secondary Schools in Kano.

The Mathematics Achievement Test (MAT) was used to collect data on the effects of Gagne's Learning Hierarchy onStudents' level of Retention in Mathematics, among Senior Secondary Schools in Kano and the summary of the analysis is presented in table 1.10, using frequency (N), Mean ($\bar{x}$), Standard Deviation (SD) and Z - test.

Table 5: Summary of the post-posttest results of the independent sample z-test on the effectiveness of Students' level of Retention in Mathematics, among Senior Secondary Schools in Kano when expose to Gagne's Learning Hierarchy

Group	POST-POSTTEST					
	N	$\bar{x}$	SD	Df	Z	P-value
EXP.	145	33.37	3.391			
				276	12.82	0.000
CON.	133	26.87	4.865			
TOTAL	278					

Results from table 5 revealed that,in the post-posttest, there was significant difference between the experimental and the control groups with p-value 0.00 which is less than the level of significant (α=0.05). The result further revealed that, the mean score (33.37) of the experimental group is higher than the mean score (26.87) of the control group with the difference of 6.50. Therefore, Gagne's learning Hierarchy has significant effect on Students' level of Retention in Mathematics. As such, hypothesis one is rejected.

Hypothesis Four: There is no significance difference on the effects of Gagne's Learning Hierarchy on Students' level of Retention in Mathematics, based on Gender among Senior Secondary Schools in Kano.
The Mathematics Achievement Test (MAT) was used to collect data on the effects of Gagne's Learning Hierarchy on Students' level of Retention in Mathematics, based on Gender among Senior Secondary Schools in Kano and the summary of the analysis is presented in table 1.11, using frequency (N), Mean ($\bar{x}$), Standard Deviation (SD) and Z - test.

Table 6: Summary of the post-posttest results of the independent sample z-test on the effectiveness of students' level of Retention in Mathematics, based on Gender among Senior Secondary Schools in Kano, when expose toGagne's Learning Hierarchy.

Group	POST – TEST					
	N	$\bar{x}$	SD	Df	Z	P-value
MALE	75	32.49	3.95			
				143	-5.457	0.000
FEMALE	70	35.30	2.40			
TOTAL	145					

Result from table 6 showed that, in the Post-posttest, the mean score (32.49) of the male Students is less than the mean score (35.30) of the female Students, also the p-value (0.00) is less than the level of significance (α=0.05). This shows that there was difference in Retentionbetween the boys and girls when exposed Mathematics using the Gagne's Learning Hierarchy. In addition, there was significant difference in students' level of Retention in Mathematics, based on Gender among Senior Secondary Schools in Kano, when exposed

to Gagne's Learning Hierarchy, Therefore, hypothesis four was rejected.

V. CONCLUSIONS
Based on the findings of this study, the following conclusions were drawn:
1. From table 2, the analyses revealed that,Gagne's learning Hierarchy has significant effect on students' academic achievement in Mathematics and is effective in teaching Mathematics than Conventional method.

2. From table 2, the analyses revealed that,there was no difference in the achievement of boys and girls when exposed Mathematics using the Gagne's Learning Hierarchy.
3. From table 3, the analyses revealed that, Gagne's learning Hierarchy has significant effect on Students' level of Retention in Mathematics
4. From table 4, the analyses revealed that, there was difference in Retention between the boys and girls, thus, the method has significant difference in students' level of Retention in Mathematics, based on Gender when exposed to Gagne's Learning Hierarchy.

Recommendation from study
Based on the findings of the study, the following recommendations were made:
1. Gagne's Learning Hierarchy should be adapted by mathematics teachers to teach Mathematical concepts to insure the effectiveness of the method in the teaching of mathematics.
2. School management should encourage their teachers to use Gagne's Learning Hierarchy in their schools in teaching Mathematics taking into consideration the gender gaps or gender differences in the subject.
3. FME, SME, NCM, MAN and STAN should organize regular workshops on Gagne's Learning Hierarchy to secondary school teachers to show them how effective it is andshould encouraged Mathematics text book authors to incorporate Gagne's Learning Hierarchy as progressive and successful strategy of teaching mathematics by showing its effectiveness.

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