Effect of Gagne's Learning Hierarchy on Chemistry Student Achievement in Senior Secondary School

CHINDA, WOROKWU
Department of Chemistry, Faculty of Natural and Applied Sciences, Ignatius Ajuru University of Education, P.M.B.5047, Rumuolumeni, Port Harcourt, Rivers State, Nigeria

Abstract- ***The study investigated the effect of Gagne's hierarchical learning strategy on the academic achievement of chemistry students among senior secondary school students in Obio/Akpor local government area of Rivers State Nigeria. The design of the study was quasi-experimental, specifically pretest, posttest control experimental group design. The population of the study consists of all the SSII Chemistry students. The sample size was ninety–eight students via simple random sampling technique. There were 47 students in the experimental group and 51 students in the control group. Two research questions and two hypotheses guided the study. Chemistry Achievement Test (CAT) was the instrument used for data collection. At the end of the treatment, study subjects were post-tested. which is a 30 multiple choice objective test questions which were well-validated and had a reliability co-efficient of 0.90 on the Cronbach alpha technique were administered to the students in the two groups before and after the application of the teaching strategies on the two groups. Mean, standard deviation, and t-test were the statistical tools used for data analysis to determine any significant difference in their academic performance in the experimental group. The results indicated that the performance of students taught electrolysis using Gagne hierarchical learning strategy was significantly better. Students' gender had no significant effect on their performance in chemistry when Gagne's hierarchical learning strategy is used. Based on the findings the study, therefore, recommends among others, in-service training for science teachers in form of seminars, workshops, and conferences that should focus more on how to use the Gagne hierarchical learning strategy for the teaching of Chemistry concepts. In addition, the use of lecture method by science teachers should be minimized and done with caution to avoid underachievement and negative attitudes among science students toward Chemistry.***

Indexed Terms- ***Gagne's Learning Hierarchy, Chemistry and Academic achievement***

I. INTRODUCTION

Robert Gagne's theory of learning is often referred to as Gagne's theory of learning hierarchy. He states that "the learning of a new concept or skill depends upon the mastery of prerequisite concepts". This implies that prior (i.e., previous) knowledge determines what further learning can take place, which also indicates that materials meant for learning must be sequentially structured by the teacher (Nwanekezi & Arokoyu 2014). Gagne emphasizes the importance of task analysis of instructional objectives. He also believes in task analysis of the concepts, skills, and knowledge to be taught.

Gagne's theory believes that materials meant for learning (i.e., learning task) should be sequentially structured so that the learning of one topic (i.e., acquisition of one knowledge) aids the learning of the next higher-order topic (i.e., acquisition of the next higher knowledge). This invariably implies that learning must be sequentially structured by the teacher from simple to complex until the desired objective is achieved. In Gagne's theory of learning, problem-solving is the highest level while lower levels involve facts, concepts, and generalization.

Gagne's theory also advocates the administration of pre-test to find out whether the students possess the relevant prerequisites for the next knowledge (i.e., higher-order knowledge). The result of the pre-test will help the teacher to know the entry point for learning to begin in the hierarchy of learning tasks. Gagne also suggests that in a teaching situation the

teacher should begin with a question like, “what is it that I want the learner to be able to do?” this implies that there must be well-stated performance objectives in every lesson.

Gagne’s theory stipulates that there are several types and levels of learning, and each of these types and levels requires instruction that is tailored to meet the needs of the learner. While Gagne's learning blueprint can cover all aspects of learning, the focus of the theory is on the retention and honing of intellectual skills. The theory has been applied to the design of instruction in all fields, though in its original formulation special attention was given to military training settings

- Condition of Learning

This theory stipulates that there are several different types or levels of learning. The significance of these classifications is that each different type requires different types of instruction. Gagne identifies five major categories of learning: verbal information, intellectual skills, cognitive strategies, motor skills, and attitudes (Driscoll, 1994). Different internal and external conditions are necessary for each type of learning. For example, for cognitive strategies to be learned, there must be a chance to practice developing new solutions to problems; to learn attitudes, the learner must be exposed to a credible role model or persuasive arguments.

Gagne suggests that learning tasks for intellectual skills can be organized in a hierarchy according to complexity: stimulus recognition, response generation, procedure following, use of terminology, discriminations, concept formation, rule application, and problem-solving. The primary significance of the hierarchy is to identify prerequisites that should be completed to facilitate learning at each level. Prerequisites are identified by doing a task analysis of a learning/training task. Learning hierarchies provide a basis for the sequencing of instruction.

- Gagne’s Hierarchy of Learning Types

In 1962, the American educational psychologist Robert M. Gagné proposed a system of classifying different types of learning in terms of the degree of complexity of the mental processes involved. He identified eight basic types and arranged these in the hierarchy shown in Figure 1. According to Gagné, the higher orders of learning in this hierarchy build upon the lower levels, requiring progressively greater amounts of previous learning for their success. The lowest four orders tend to focus on the more behavioral aspects of learning, while the highest four focus on the more cognitive aspects.

The most complete description of Gagne’s classes of behavior appears in his ‘The conditions of learning’. Here he distinguishes eight types of learning, beginning with the simple forms and ending with the complex. Although he refers to these classes as learning types, he is primarily interested in the observable behavior and performance which are the products of each such class.

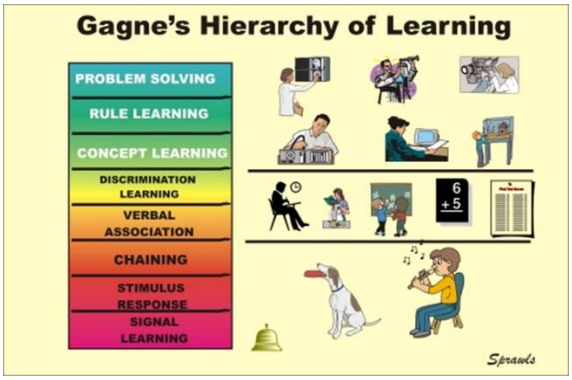

Fig1: Robert Gagne’s Theory of Learning Hierarchy

- Signal Learning

This is the simplest form of learning and consists essentially of the classical conditioning first described by the behavioral psychologist Pavlov. In this type of learning the animal or individual acquires a conditioned response to a given signal. Pavlov studied such learning in great detail. In it the responses are diffuse and emotional and the learning is involuntary. Examples are the withdrawal of the hand upon sight of a hot object, the salivation of a dog upon hearing food poured into his metal feeding dish, and the tearing of the eyes upon sight of an onion. The signals are the sight of the hot object, the sound of food being poured into the dish, and the sight of the onion. The conditioned responses are withdrawal of the hand, salivation, and tearing of the eyes.

- Stimulus-Response Learning

This somewhat more sophisticated form of learning, which is also known as operant conditioning, was originally developed by Skinner. In this kind of learning, exemplified by animal training, the animal makes precise responses to specific stimuli. At first, this training usually requires the use of a leash and a choke chain. As the dog learns particular responses to particular jerks of the leash and chain, his master rewards him with pats and praise. Later the master does not have to use the leash and chain; the animal sits, stays, or lies down upon hearing the simple verbal command. Whereas the responses in signal learning are diffuse and emotional, the responses in stimulus-response learning (often called operant conditioning) are fairly precise. Stimulus-response (SR) learning may be used in acquiring verbal skills as well as physical movements. For example, the child may learn to say "Mama" on request, or an adult may learn the appropriate response to the stimulus of a word in a foreign language (Driscoll, 1994)

- Chaining

This is a more advanced form of learning in which the subject develops the ability to connect two or more previously-learned stimulus-response bonds into a linked sequence. It is the process whereby most complex psychomotor skills (e.g., riding a bicycle or playing the piano) are learned. In this type of learning the person links together previously learned S-R's. The links may involve physical reactions such as an animal learning a series of tricks, each of which gives the cue to perform the next trick. This type of learning often seems to occur so naturally that we do not notice the specific series of events that led to it. Gagne uses the example of a child who learns to say "doll" at the sight of a doll, then learns to lie down, hug the doll, and say "doll".

- Verbal Association

This is a form of chaining in which the links between the items being joined are verbal in nature. Verbal association is one of the main methods in the development of language skills. This knowledge is a type of chaining, but the links are verbal units. The simplest verbal association is the activity of naming an object, which involves a chain of two links: An observing response enables the child to identify properly the object he sees, and an internal stimulus enables the child to say the proper name. When the child can name an object "ball" and also say "the red ball" he has learned a vernal association of three links. Gagne calls another shared verbal association *translation response*; in these, the learner regularly finds verbal associations by verbal facilitation- an internal link that helps him associate.

- Discrimination Learning

This involves developing the ability to make suitable (different) reactions to a series of related stimuli that differ in a systematic way. The process is made more difficult (and hence more difficult) by the phenomenon of meddling, whereby one piece of learning prevents another. Interfering is thought to be one of the main causes of being unable to remember. In this type of learning the student must learn different responses to stimuli that might be confused. The student learns to distinguish between motor and verbal chains he has already acquired. Teachers, Gagne suggests, engage in discrimination learning when the device means calling each student by his correct name.

- Concept Learning

This involves developing the ability to make a consistent response to different stimuli that form a common class or category of some sort. It forms the basis of the ability to generalize, classify, etc. In learning a concept, we react to stimuli in terms of abstract characteristics like color, shape, position, and number as opposed to concrete physical properties like specific wavelengths or particular intensities. In concept learning the student's behavior is not under the control of particular physical stimuli but of the abstract properties of each stimulus. Concepts have concrete references even though they are learned with the use of language.

- Rule Learning

This is a very high-level cognitive process that involves being able to learn relationships between concepts and apply these relationships in different situations, including situations not previously encountered. It forms the basis of the learning of general rules, procedures, etc. In learning a rule, we relate two or more concepts. Rules are, in effect, chains of concepts. We may represent knowledge as a

hierarchy of rules, in which we must learn two or more rules before learning a higher-order rule which embraces them. If the student has learned the component concepts and rules, the teacher can use verbal instruction alone in leading the student to put the rules together (Khadjooi, Rostami & Ishaq,2011).

- Problem Solving

This is the highest level of the cognitive process according to Gagne. It involves developing the ability to invent a complex rule, algorithm, or procedure for the purpose of solving one particular problem, and then using the method to solve other problems of a similar nature.

In the set of events called problem-solving, individuals use rules to achieve some goal. When the goal is reached, however, the student has learned something more and is then capable of new performances using his new knowledge. What is learned, is a higher-order rule, the combined product of two or more lower-order rules. Thus, problem-solving requires those internal events usually called thinking. Without knowledge of the prerequisite rules, the problem cannot be solved.

Gagne identifies five major categories of learning:
Gagne identifies five major categories of learning: verbal information, intellectual skills, cognitive strategies, motor skills, and attitudes. ... In addition, the theory outlines nine instructional events and corresponding cognitive processes: Gaining attention (reception)

- Gagne's model of instructional design

Robert Gagne is considered to be one of the foremost contributors to the systematic approach to instructional design and his theory has provided a great number of valuable ideas for trainers and teachers. Gagne's model of instructional design is based on the information processing model of the mental events that occur when adults are presented with various stimuli and focuses on the learning outcomes and how to arrange specific instructional events to achieve those outcomes. Gagne's theories have been applied to the design of instruction in several domains, such as the military, flying, leadership, engineering and healthcare.

Essential to Gagne's ideas of instruction are what he calls “conditions of learning”: internal conditions deal with what the learner knows prior to the instruction, external conditions deal with the stimuli that are presented to the learner, e.g. instructions provided by the teacher.

The first step in Gagne's theory is specifying the kind of outcomes to be achieved. He categorized these outcomes into five types: verbal information, intellectual skills, cognitive strategies, attitudes, and motor skills.

Gagne, Briggs and Wager (1992) identified the second step is to establish suitable instructional events. Gagne's “Events of instruction” entail the following:

1. Gaining attention
2. Informing the learner of the objective
3. Stimulating recall of prerequisite learning
4. Presenting the stimulus material
5. Providing learning guidance
6. Eliciting the performance
7. Providing feedback
8. Assessing the performance
9. Enhancing retention and transfer

Inserting a peritoneal drain is a motor skill, which corresponds to affective and psychomotor skill outcomes. The ideal number of learners for this kind of session is 4 or 5. The following instructional events can be organized for a lesson to teach the insertion of a peritoneal drain:

Gagne's model of instructional design is based on the information processing model of the mental events that occur when adults are presented with various stimuli and focuses on the learning outcomes and how to arrange specific instructional events to achieve those outcomes. Applying Gagne's nine-step model is an excellent way to ensure an effective and systematic learning program as it gives structure to the lesson plans and a holistic view to the teaching. we use Gagne's “events of instruction” to design a lesson plan for this subject.

- Gagne's Theory of Instruction

Gagne's theory of instruction is commonly broken into three areas. Gagne's taxonomy of learning outcomes is somewhat similar to Bloom's taxonomies of

cognitive, affective, and psychomotor outcomes (some of these taxonomies were proposed by Bloom, but actually completed by others). Both Bloom and Gagne believed that it was important to break down humans' learned capabilities into categories or domains. Gagne's taxonomy consists of five categories of learning outcomes - verbal information, intellectual skills, cognitive strategies, attitudes, and motor skills. Gagne, Briggs, and Wager (1992) explain that each of the categories leads to a different class of human performance.

Essential to Gagne's ideas of instruction is what he calls "conditions of learning." He breaks these down into internal and external conditions. The internal conditions deal with the previously learned capabilities of the learner. Or in other words, what the learner knows prior to the instruction. The external conditions deal with the stimuli (a pure behaviorist term) that are presented externally to the learner. For example, what instruction is provided to the learner?
To tie Gagne's theory of instruction together, he formulated nine events of instruction. When followed, these events are intended to promote the transfer of knowledge or information from perception through the stages of memory. Gagne bases his events of instruction on the cognitive information processing learning theory.

Robert Gagne's theory of instruction has provided a great number of valuable ideas to instructional designers, trainers, and teachers. The way Gagne's theory is put into practice is as follows. First of all, the instructor determines the objectives of the instruction. These objectives must then be categorized into one of the five domains of learning outcomes. Each of the objectives must be stated in performance terms using one of the standard verbs (i.e. states, discriminates, classifies, etc.) associated with the particular learning outcome. The instructor then uses the conditions of learning for the particular learning outcome to determine the conditions necessary for learning. And finally, the events of instruction necessary to promote the internal process of learning are chosen and put into the lesson plan. The events in essence become the framework for the lesson plan or steps of instruction.
very well for them. For the concepts in chemistry to be taught efficiently to chemistry students in the secondary schools, Gagne's theory of learning hierarchy of science teaching and learning has been deemed appropriate and successful (Kearsely 1999). Gagne's theory of learning hierarchy has promoted a hierarchical organization where students are exposed to serval concepts from simple to complex concepts. Robert Gagne's theory of learning is often referred to as Gagne's theory of learning hierarchy (Kearsely, 1994). According to Gagne, the learning of a new concept or skill is determined by the mastery of pre-requisite concepts that are hierarchically arranged. This advocates that prior knowledge regulates what further learning may take place, which also implies that resources meant for learning must be in sequence structured by the teacher. The importance of Gagne's learning hierarchy in the teaching of chemistry is that it will permit students to attain meaningful learning through the movement from prior learned material to abstract material. For instance, before the Senior Secondary School students comprehend the concept of balancing chemical equations (abstract material), they must be familiar with lower concepts/prerequisites, like concepts of atoms, molecules, compounds, ions, symbols, atomic numbers, simple chemical combination and so on (previously learned material) (Sabiru,2013). And the organization 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 the electrolysis in Chemistry, with the hope of enhancing the academic performance of the students on the topic,

Sabiru (2013) studied the effects of using the Gagne learning hierarchy on Chemistry student academic achievement and anxiety levels in balancing chemical equations in secondary schools in Kastina metropolis Nigeria. The study adopted the pretest – post-test design. The sample size for the study was 100 SSII students from two secondary schools in Kastina. The instrument for data collection was the Balancing Chemical Equation Achievement Test (BCEAT) and the Students Anxiety Scale Questionnaire (SASQ). The reliability co-efficient of the instruments was 0.79 and 0.78 via Pearson Product Moment Correlation. Two research questions and two hypotheses guided the

study. The data collected were analyzed using mean, standard deviation, and t-test. The result of the study reveals that there is a significant difference in the achievement of students taught balancing chemical equations with Gagne's learning hierarchy than those taught with the lecture method. The result further reveals that students taught with Gagne's learning hierarchy have low anxiety than their counterparts taught with the lecture method. The study recommends that Gagne's learning hierarchy should be used to teach Chemistry as it enhances academic achievement and reduces the level of anxiety.

Attah (2014) investigated the effects of two teaching methods on secondary school students' achievement in writing and balancing chemical equations in the Nsukka Education zone of Enugu Nigeria. The study adopted the pretest-posttest non-equivalent control group design. The sample size was eighty SS1 students. Four research questions and six hypotheses guided the study. The instrument for data collection was a Chemistry achievement test. The data generated were analyzed using mean, standard deviation, and ANCOVA. The results reveal that the demonstration method is efficient in teaching balancing of chemical equations. Gender does not influence students' achievement and retention in balancing chemical equations. It was recommended that the demonstration method should be employed by Chemistry teachers to teach the balancing of chemical equations and other concepts.

Eyenaka, Ekanem and Uwak (2013), studied Context-Based Strategy (CBS) for effective learning of simple alternative current (A.C.) circuits in senior secondary school Physics. The study was carried out in Ikpot Ekpene Akwa Ibom State Nigeria. The study adopted a quasi-experiment design specifically a non-equivalent pre-test-posttest control group design. Three hypotheses guided the study. The sample size of the study was 450 students via a stratified random sampling technique.

The instrument for data collection was simple alternating current (AC) Circuits in Physics Achievement Tests (SACPATS). The instrument has a reliability coefficient of 0.56 via Kuder Richardson formula 20. The data gathered was analyzed using mean, standard deviation, and t-test. The results show that students taught simple alternating current. Circuit with context-based teaching strategy achieved higher than those taught with expository method. The result reveals that gender is significant in the achievement of students in Physics while the location is not significant in the achievement of students in simple alternating current circuits. The study recommends that Physics teachers should adopt the context-based teaching strategy in teaching simple alternating current (AC) circuits and other concepts since it improves students' achievement in physics.

Duban, Ayogdu and Yukel (2019) studied classroom teachers' opinions on science laboratory practices. The study was carried out in schools in Atyom Kacetepe Turkey. The study adopted the phenomenological design. The sample size was 18 teachers and six group class teachers working in public schools. The interview technique was used for data collection to find out the different instructional approaches they employ in teaching laboratory practical. The data gathered were analyzed using quantitative data analysis. The finding of the study reveals that laboratory practical was carried out in the classroom using innovative strategies. It was also revealed that safety measures must be adopted in laboratory practical. The study recommends that laboratories should be increased in schools.

Tang, Tsai and Huang (2020), examined inheritance coding with a Gagne-based learning hierarchy approach to developing mathematical skills assessment system. The study was carried out in Taiwan. The study was aimed at proposing effective theoretical methods to construct processes and establish assessment systems. Two research questions guided the study. The instrument for data collection was an inherited coding approach and the ADDIE model for the system development process. The reliability coefficient of the instrument was 0.8 via Cronbach alpha. The population for the study was grade 5 and 6 students in Pingtung and Kaohsiung Taiwan. The data gathered was analyzed using the test Pearson product-moment correlation and simple percentages. The finding revealed that student achievement was high however many mistakes were made. The assessment system helps in diagnosing student learning difficulties and provided the teacher with ways of improving learning effectiveness. The

study concludes the Gagne learning hierarchy theory and inherited coding approach provided a method of building mathematical skills and also diagnosing students learning problems.

Ugwu (2015) worked on the comparative effectiveness of two instructional approaches on science students' achievement and attitude. His sample was composed of 570 form four students from six secondary schools in Aguata Local Government Area of Anambra State of Nigeria. The data collected were analyzed using analysis of variance (ANOVA), analysis of covariance (ANCOVA), and post hoc comparison test. The result indicated that:

i. Inquiry-based or open classroom and refined conventional approach were viable alternatives to science teaching and are both superior to the traditional approach.
ii. Outdoor laboratory approach is better for teaching low-ability students.
iii. Outdoor laboratory approach promotes a positive attitude to science by students. The findings of this study imply that the outdoor laboratory teaching which is activity-oriented is a better strategy for promoting the understanding of science as well as a positive attitude to science.

Adeyemi (2018) also investigated the effect of Gagne's hierarchical learning strategy and expository instructional methods on the attitude of students to biology. He used 240 SSI students of biology randomly drawn from six schools in Oyo State, Nigeria. He used a 40-item scientific attitude questionnaire with a five-point scale. He found out that, the experimental groups i.e., those taught using Gagne hierarchical learning strategy had a significantly more favorable attitude to biology than the control group, in addition, the study revealed a nonsignificant difference in attitude between male and female students exposed to the two teaching methods. Olorukooba, (2017) conducted a study to find out the attitude of students toward the use of cooperative, competitive and individualistic learning strategies in Nigerian Senior Secondary School Physics. He used a quasi-experimental design. A total of 140 students consisting of 66 males and 77 females were selected by a random sampling technique from a population of 680 senior secondary two (SSII) Physics students drawn from all the 13 co-educational secondary schools in Ife South Local Government area of Osun State, Nigeria. The data collected were analyzed using Analysis of Variance (ANOVA) and the result of the findings showed that the cooperative learning strategy was the most effective in facilitating students' attitude toward Physics. This was followed by competitive strategies with the individualistic learning strategies being the least facilitative. The result also showed an insignificant gender difference in the attitude of students toward Physics when taught with cooperative, competitive, and individualistic strategies

Nwaobi (2017) conducted a study on Gagne's hierarchical learning strategy and students' academic achievement in biology. The study adopted a quasi-experimental design comprising of 120 senior secondary I students of Ogba/Egbema/Ndoni Local Government Area of Rivers State, Nigeria. The sample was selected from four schools drawn from the fifteen secondary schools in Ogba/Egbema/Ndoni Local Government Areas using a stratified random sampling technique. Students were randomly assigned to two groups (treatment and control groups). The study shows that Gagne hierarchical learning strategy has a significant effect on students' achievements in biology and that the use of Gagne's hierarchical learning strategy favours the male more than the female in biology achievement.

Therefore, it is in agreement with the above brief that the researchers consider it essential to investigate students' understanding of electrolysis of Gagne hierarchical learning.

Accordingly, to give direction to this study the following research questions and hypotheses served as a guide for the study.

Research question

1. What is the mean difference in the academic performance between students taught Chemistry with Gagne hierarchical learning and those taught with lecture method?
2. What is the mean difference between male and female students taught Chemistry using Gagne hierarchical learning?

- Hypotheses

To answer the research questions of the study the following null hypotheses were formulated and tested at 0.05 level of significance.

1. There is no significant difference in the academic performance between students taught Chemistry with Gagne hierarchical learning and those taught with lecture method
2. There is no significant difference between male and female students taught Chemistry using Gagne hierarchical learning

II. METHODOLOGY

- Research design

The design of this study is quasi-experimental. Specifically, pretest, post-test control group Senior Secondary School in Rivers State.

- Area of Study

The study was conducted in Senior Secondary Schools in Obio/Akpor Local Government Area of Rivers State.

- Population the Study

The population of this study consisted of all the Senior Secondary School II Chemistry students in all Public Secondary Schools in Obio/Akpor Local government Area of Rivers.

- Sampling/Sampling Technique

Simple random sampling technique was used to select two schools for the experimental and control group. Two intact classes were randomly selected the SS2 from each school. A sample of 98 Senior Secondary (SS2) chemistry students was used for the study.

- Research Instrument

The research instrument used to collect data for the study was the Chemistry Achievement Test (CAT). However, a 30-item multiple-choice objective test with four options developed by the researcher was used.

- Validation of the Instrument

The test instruments used in the study were validated by two expert persons: A Chemistry teacher from the carefully chosen schools and also a Chemistry Education lecturer at the Ignatius Ajuru University of Education, Rumuolumeni, so as to meet both face and content validation. and had a reliability co-efficient of 0.90 on Cronbach alpha technique

- Data Collection

Students in the experimental group were taught Electrolysis with Gagne hierarchical learning strategies while students in the control group were taught with traditional methods. Post-test scores were collected after three weeks of treatment.

- Data Analysis

The scores obtained from the pre-test and post-test were analyzed using mean and standard deviation to answer the research questions while the t-test was used to test the hypotheses for the significant difference at 0.05 level.

III. RESULTS

Research question 1: What is the mean difference in the academic performance between students taught chemistry with Gagne hierarchical learning and those taught with lecture method?

Table 1: Mean and standard deviation showing academic performance of students

Group	N	Mean	SD	Std. Error Mean
Experimental	47	42.23	5.031	.733
Control	51	29.47	6.821	.955

The data on students' achievement in Table 1 revealed that students taught Basic science using Gagne hierarchical learning had a mean score of 42.23 with a standard deviation of 5.03 while the mean achievement score of students taught with the conventional lecture method was 29.47 with a standard deviation of 0.95. Students taught Chemistry using Gagne hierarchical learning method, therefore, performed better than students taught using the conventional lecture method.

Research question 2: What is the mean difference between male and female students taught chemistry using Gagne hierarchical learning?

Table 2: Mean and standard deviation showing academic performance of students based on gender

Gender	N	Mean	SD	Std. Error Mean
Male	27	41.66	4.835	.93064
Female	20	43.00	5.311	1.18766

Data in Table 2 revealed a mean achievement score of 41.66 with a standard deviation of 4.83 for male students, while the female students had a mean achievement score of 43.00 with a standard deviation of 5.31. The academic performance of male and female students in the experimental group was equivalent.

Table 3: t-test showing students' academic performance

Group	N	Mean	SD	Df	t-cal	Sig	Decision
Experimental	47	42.23	5.031	96	10.46	0.00	S
Control	51	29.47	6.821				

From Table 3 the result revealed that the t-cal was 10.46 and a p-value of 0.00 was recorded at df = 96. Since the p-value of p=0.00 is less than 0.05, it implies that there is a significant difference in the academic performance between students taught chemistry with Gagne hierarchical learning and those taught with the lecture method. Thus, the null hypothesis that says there is no significant difference is rejected.

HO2: There is no significant difference between male and female students taught chemistry using Gagne hierarchical learning

Table 4. t-test showing male and female students' academic performance taught chemistry using Gagne hierarchical learning

	N	Mean	SD	Df	t-cal	Sig	Decision
Male	27	41.66	4.835	45	-0.89	0.957	NS
Female	20	43.00	5.311				

From Table 4 the result revealed that t-cal was -0.89 and a p-value of 0.957 was recorded at df = 96. Since the p-value of p=0.957 is greater than 0.05, it implies that there is no significant difference between male and female students taught chemistry using Gagne hierarchical learning. Thus, the null hypothesis that says there is no significant difference is accepted.

- Discussion of the Results

In Table 1 the result of testing hypothesis one shows that there is a significant difference in the mean academic achievement scores of students exposed to Gagne hierarchical learning and those taught with the lecture method. The significant difference found between the two groups is likely to be due to the use of the Gagne hierarchical learning strategy (an activity-oriented method) in the experimental group. If the treatment administered has no effect, the two groups are expected to perform equally the same. Since the experimental group performed significantly better, it implies that using Gagne hierarchical learning in teaching students improves their performance. The result confirms the earlier finding of Sabiru (2013,) and Ugwu (2015) who recommended that students should be provided with the appropriate method of instruction in science such as the Gagne hierarchical learning strategy in order to make abstract concepts better understood. Similarly, Nwaobi (2017) Tang, Tsai and Huang (2020) affirm that these strategies help in diagnosing student learning difficulties and provided the teacher with ways of improving learning effectiveness.

On the issue of gender in relation to academic achievement when Gagne hierarchical learning and lecture method, the results in table 4. show that Gagne hierarchical learning enhances the academic performance of both male and female students in Chemistry. This finding is in agreement with the findings of Attah (2014) and Adeyemi (2018) that found that there is no gender difference in the academic achievement of students when exposed to activity-based methods of instruction such as guided inquiry, problem-solving and process approach. The result of this study is in contrast with Eyenaka, Ekanem and Uwak (2013) who reveal that gender is significant in the achievement of students in Physics

- Conclusion and recommendation

This study investigated the effect of Gagne's hierarchical learning strategy on the academic achievement of chemistry students among senior secondary school students. It also investigated the effects of gender-related differences on students' academic achievement in the teaching of concepts of chemistry using the Gagne hierarchical learning strategy.

The results indicated that the performance of students taught organic concept using Gagne hierarchical learning strategy was significantly better. Students' gender had no significant effect on their performance in chemistry when Gagne's hierarchical learning strategy is used. Based on the findings the study, therefore, recommends among others, in-service training for science teachers in form of seminars, workshops, and conferences should focus more on how to use Gagne hierarchical learning strategy for the teaching of chemistry concepts. In addition, the use of lecture method by science teachers should be minimized and done with caution to avoid underachievement and negative attitude among science students to chemistry.

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