

RESEARCH ARTICLE

EFFECTS OF SCAFFOLDING INSTRUCTIONAL STRATEGY, COGNITIVE LEARNING STYLES AND INTELLIGENCE ON STUDENTS' ACHIEVEMENT IN GENETICS IN NORTH SENATORIAL DISTRICT, BENUE STATE, NIGERIA

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Abstract

..... This study compared the Effects of Scaffolding Instructional Strategy, Cognitive Learning Styles and Intelligence on Students' Achievement in Genetics in North Senatorial District, Benue State, Nigeria. A 2×2×2 (Method×Cognitive learning style×Intelligence) pre-test post-test group quasi experimental design was adopted for this study. The population of the study comprised 1,957 SSIII in public co-educational schools in North Senatorial District, Benue State, Nigeria. The sample of the study comprised 83 SSIII students randomly sampled from two intact classes randomly selected from public co-educational schools in North Senatorial District, Benue State, Nigeria. Three instruments were employed for data collection, namely; Standard Progressive Matrices (SPM), Cognitive Style Checklist (CSC) and Genetics Achievement Test (GAT). The reliability coefficient of SPM and CSC were determined through test-retest and the reliability coefficient of 0.79 and 0.76 were obtained. The reliability of GAT was determined using Kuder-Richardson formula 20 (KR20) and the reliability coefficient of 0.80 was obtained. Descriptive statistical techniques of mean and standard deviation, Kolmogorov-Smirnov test (K-Stest) was used to ascertain the normality of the distribution of achievement scores. An Analysis of Variance $(2 \times 2 \times 2)$ was employed on the scores of the students to test the hypothesis at 0.05 level of significance. The findings of this study revealed that the achievement of the scaffolding instructional strategy group was found to be significantly higher than the group taught through traditional method of teaching. Also the findings revealed that the difference of achievement was significant at two levels of cognitive styles. It was also revealed that the achievement gain scores of high intelligence group were significantly higher in comparison to low intelligence group. Based on the findings of this study it was recommended that scaffolding instructional strategy should be used by Biology teachers in the teaching Genetics.

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Introduction:-

Genetics is the study of heredity and variation in living organisms. The passing on and expression of traits or characters from parents to offspring is termed heredity or inheritance. Heredity or inheritance may give rise to differences among individual organisms, this is term hereditary variations (Latta, 2010; Mader, Umeh, 2011; Nworgu, 2012; Tian, 2014 & Bayers, 2015). The genetical knowledge acquired by man enable him to embark on series of technologies for his utilization such as the selection of different strains of plants or animal species for the purpose of cross breeding to improve the structure, function, or yield of organism for economic importance to human life. The knowledge has enabled geneticists to determine blood groups paternity there by leading to counselling of patient, finger prints detection often used in crime detection, production of test tube baby, rhesus factors in sex determination, drugs and medical preparations obtained from animal tissues and other organic sources for human utilization. It has also enabled geneticist to discovered diabetes, sickle cell anemia, human DNA, blood group of individual donors and recipients using genetics crossing and agglutination or blood transfusion in human beings (Mader, Umeh, 2011; Simon, 2015 & Mader, 2016).

The problems associated with low achievement in genetics were students' lack of interest and inability to retain most genetics concepts learnt, as identified by (Nworgu, 2012; Stephen, 2014) which according to them, can be traced to both teachers and students related problems. These problems include:

Inability of biology teachers to put across the teaching of biology concepts correctly to learners due to abstract nature of some topics, how to relate structure to function and lack of biology teachers' professional development training.

- 1. Lack of professional skills and competence for teaching some biological concepts.
- 2. Lack of pre-requisite knowledge for genetics.
- 3. Students' attitude (forbear) towards genetics as a branch of biology.
- 4. Lack of laboratory equipment and apparatus.
- 5. Biology teachers' persistent use of conventional teaching method.

The WAEC Chief Examiners Report comments for the year 2017, on genetics questions attempted by students, categorically stated that many candidates could not state possible genotypes of the father. Conclusively candidates achieved poorly on question of genetics. The same situation occurred in West Africa French speaking countries where students' achievement in genetics was poor, Chief Examiner's Report (2013). Subsequently, the West Africa Examination Council (WAEC), Chief Examiner's Report (2015, 2016 & 2017) comments on genetics achievement were all very poor. Studies revealed that low achievement in genetics has been attributed to attitudinal problem of students, superstitions belief, cognitive and socio-economic problem of teachers, administrative policy makers and instructional strategy among others (NECO, 2018; Stephen, 2014).

Scaffolding is an instructional strategy that emphasizes the teaching of new skills by engaging students collaboratively in tasks that would be too difficult for them to complete on their own. The teaching strategy emphasizes on the role of teachers and other more skillful persons in supporting the learner's development and providing support structures to get to that next stage or level (Nonye & Nwosu, 2011). The instructional strategy originated from Lev Vygotsky socio-culture theory and his concept of Zone of Proximal Development (ZPD). His socio-cultural theory spelt out that social interaction plays an important role in the development of cognition. In his view, the learner does not learn in isolation, rather learning is strongly influenced by social interactions, which take place in meaningful contexts. The Zone of Proximal Development (ZPD) is that area between what a learner can do independently (masterylevel) and what can be accomplished with the assistance of a competent adult or peer (Instructional level). It is believed that any learner could be taught any concept effectively using instructional scaffolding strategy by applying the scaffolding at the ZPD.

Scaffolding as an instructional strategy depends heavily on the ideas that learners come to any educational setting with a great deal of pre-existing knowledge, some of which may be incorrect. It is the process of building on what a learner already knows that makes scaffolding an effective instructional technique. According to Olson and Prath (2000) and Casem (2013), in scaffolding instruction, a more knowledgeable person provides scaffolds to facilitate the learner's development. These can be in the form of support which may include resources, acompelling task, templates, and guides, guidance on the development of cognitive and social skills. The scaffolds facilitate students' ability to build on prior knowledge and internalize new information. The activities provided in scaffolding instruction are just beyond the level of what the learner can

do alone. An important aspect of scaffolding is that the scaffolds are temporary. Ibritam, Udofia, and Onweh (2015) asserted that as the learners' abilities increases, the scaffolding provided by the more knowledgeable person is progressively withdrawn. Finally, the learner is able to complete the task or master the concept independently.

Cognitive learning style is a psychological construct which is concerned with how an individual learns, thinks, solve problems, remembers and relates to others. It represents the individual differences in the various subcomponents of an information-processing model of three main cognitive processes: perception, memory and thought. Cognitive learning style is considered to be personality dimension that influences attitudes, values and social interaction. It is an individual characteristic mode of perceiving and processing information in the environment (Hall, 2000). An individual is either Field-independent (FI) or Field-dependent (FD). A Field-independent (FI) cognitive learning style learner is described as analytic, competitive, individualistic, task-oriented, internally referent, intrinsically motivated (self-study), self-structuring, detail oriented and visually perceptive, prefers individual project work and has poor social skills; while Field-dependent (FD) cognitive learner is described as global (wholistic), group-oriented, sensitive to social interactions and criticisms, externally motivated, externally referential, not visually perceptive, a non-verbal and passive learner who prefers external information and group projects (Hall, 2000; Calcaterra, Antonetti & Underwood, 2005; Guisande, Paramo, Tinajero & Almedida, 2007). A summary of the differences between the two dimensions of cognitive learning styles (Field Dependence and Field Independence) is shown in Table 1.

Field dependence (fd) (non-analytic)	Field independence (fi) (analytic)				
Have comprehensive perception	Excellent at analytical thinking				
Perceive objects as a whole and approach a task	Focus on individual parts of the object and tend to				
more wholistically	be more serialistic in their approach to learning				
Rely on external references	Rely more on internal references				
More influenced by format-structure	Less affected by format structure				
More reliant on salient cues in learning	Tend to sample more cues inherent in the field				
	and are able to extract the relevant cues necessary				
	for the completion of a task				
Likely to use active cognitive strategies	Likely to use passive cognitive strategies				
Adopt a hypothesis-testing role in learning	Adopt a spectator role in learning				
Likely to benefit from a self-directed emphasis	Tend to prefer more structured learning				
	environments				
Self-view is derived from others	Has sense of separate identity				
Not well-skilled in social/interpersonal relationships	Highly skilled in interpersonal/social relationships				

Table 1:- Differences Between Field Dependence and Field Independence Cognitive Learning Styles.

Source: Wyss (2002), Chen and McCredie, (2004)

Cognitive process styles affect how one stores knowledge and retrieves it when the need arises (Tinajero & Paramo, 2000). The students' cognitive styles may hinder or facilitate the acquisition of knowledge in Science, Technology and Mathematics (Okwo & Otuba, 2007). The achievement of students with different cognitive learning styles in a given task will determine how effective the teacher is in delivering instruction that are related to the tasks and whether the objectives of the learning is achieved.

Intelligence:-

Intelligence is a descriptive concept. It represents theoretical dimensions which may vary from very low to very high value. In common usage the word intelligence is associated with the general behaviour of an individual so that it becomes synonymous with brightness and being brainy. A psychologist, on the other hand, uses the word as theoretical construct. It is the intervening variable which can be inferred and measured by indirect operations and it has certain descriptive and predicative properties. In general intelligence conveys three messages:

- 1. Ability to adjust
- 2. Ability to learn
- 3. Ability to carry on abstract thinking Intelligence must be understood as the mental capacity or mental energy available with an individual at a particular time in a particular situation.

So we can conclude intelligence as a sort of mental energy, in the form of mental and cognitive abilities available within an individual which enables him to handle his environment in the terms of adaptation to face novel situation as effectively as possible.

Literature Review:-

Casem (2013) studied the effects of scaffolding strategy on students' performance in Mathematics. The study revealed that the students taught mathematics concepts through scaffolding performed better than those taught through lecture method. Equally, Olatubosun (2013) investigated the effects of using scaffolding strategy on the academic achievement of students in integrated science in Junior secondary school (JSS). Results showed that students exposed to scaffolding strategy performed significantly better than their counterparts who were exposed to the traditional method. Akani (2015) conducted research on the effects of instructional scaffolding on the achievement of senior secondary students in Chemistry. The result obtained revealed that there is a significant difference in the mean scores of students exposed to scaffolding instructional strategy and conventional method of instruction.

Ibritam, Udofia, and Onweh (2015) conducted a study to determine the difference in students' achievement in Block-laying and concreting using Scaffolding and Demonstration instructional methods in technical colleges. The result showed that there is no significant difference in the mean achievement scores of the students taught using scaffolding instructional strategy and those taught using instructional demonstration method. Uduafemhe (2015) undertook a study to determine the comparative effects of scaffolding and collaborative instructional approach on secondary school students' psychomotor achievement in Basic Electronics. Findings revealed that instructional scaffolding and collaborative instructional approaches are effective in improving students' achievement in Basic Electronics. However, the collaborative instructional approach was more effective than instructional scaffolding strategy. Adamu (2017) studied the effects of Analogy and scaffolding instructional strategies on senior secondary school Physics students' academic achievement. The two experimental groups were taught using Analogy and Scaffolding instructional strategies while the control group was taught using the lecture method. The finding of the study showed that there is a significant effect of treatment on students' academic achievement.

Atsumbe, Owodunni, Raymond and Uduafemhe (2018) carried out a study to determine the effects of scaffolding and collaborative instructional approaches on students' achievement in Basic Electronics. Results revealed that a collaborative instructional approach is more effective in improving student achievement in Basic Electronics than a scaffolding instructional approach. Also, gender had no significant influence on students' achievement in Basic Electronics when taught using scaffolding and collaborative instructional approaches. It was concluded that the collaborative instructional approach is a viable teaching method for improving students' achievement in Basic Electronics. Joda (2019) carried out a study to determine the effect of instructional scaffolding strategy on senior secondary school Biology Students' academic achievement and retention of concepts. The findings show that the students taught with instructional scaffolding strategy have significantly higher academic achievement than those taught with lecture method. Pandhu (2018) investigated the effect of Instruction with Scaffolding on achievement in Science in relation to cognitive styles and intelligence. The results revealed that, the achievement of the group through scaffolding instructional strategy was found to be significantly higher than the group taught through traditional method of teaching; the difference of achievement was not significant at two levels of cognitive styles and that the achievement gainscores of high intelligence group were significantly higher in comparison to low intelligence group.

Studies by Bassey, Umoren and Udida, (2013); Agboghoroma, (2015); Okoye, (2016); Owoduni, Sanni, Nwokolo and Igwe, (2016);Ezeugwu, Nji, Anyaugbunam, Enyi and Eneja, (2016);Idika, (2017); Musa and Samuel, (2019); Samuel and Musa (2019) and Agu and Samuel (2019)in their various researches reported that there is a difference between the mean achievement of Science and Mathematics students with analytical (FI) cognitive styles and those with relational and inferential (FD) cognitive styles while Ndirika (2013), opined that ability levels have no significant effect on the achievement of students. Also, Okereke (2011), Anidoh and Eze (2014) reported that cognitive styles and gender have influence of students' achievement. Panhdu (2018) investigated the effectofinstructionwithscaffoldingonschool students'achievement in science in relation to cognitivestyles and intelligence, the result revealed that cognitive styles and intelligence affect students' achievement. Nevertheless, there is no specific study on Comparative Effects of Scaffolding Instructional Strategy, Cognitive Learning Styles

and Intelligence Students' Achievement in Genetics in North Senatorial District, Nasarawa State, Nigeria, hence the need for this study.

Objectives of the Study:-

The purpose of this study is to investigate the Effects of Scaffolding Instructional Strategy, Cognitive Learning Styles and Intelligence on Students' Achievement in Genetics in North Senatorial District, Nasarawa State, Nigeria. Specifically, this study sought to;

- 1. compare the achievement of groups taught through scaffolding instructions and traditional method
- 2. compare achievement of groups having different cognitive styles.
- 3. compare the achievement of groups acrossdifferent levels of intelligence.

Research Questions:

- 1. What are the mean achievement scores of students taught genetics using scaffolding instructional strategy and those taught with the traditional method?
- 2. What are the mean achievement scores of studentswith Field-Independent (FI) and Field-Dependent (FD) cognitive learning styles when taught genetics with scaffolding instructional strategy?
- 3. What are the mean achievement scores of students with High intelligence and those with low intelligence when taught genetics with scaffolding instructional strategy?

Hypotheses:-

- 1. H_{01} : There exists no significant difference in the mean achievement scores of students taught genetics using scaffolding instructional strategy and those taught with the traditional method.
- 2. **H**₀₂: There exists no significant difference in the means of achievement scores of studentswith Field-Independent (FI) and Field-Dependent (FD) cognitive learning styles when taught genetics with scaffolding instructional strategy.
- 3. H_{03} : There exists no significant difference in the mean achievement scores of students with High intelligence and those with low intelligence when taught genetics with scaffolding instructional strategy.

Methodology:-

A $2\times2\times2$ (Method×Cognitive style×Intelligence) pre-test post-test group quasi experimental design was adopted for this study. The population of the study comprised 1,957 Senior Secondary Three (SSIII) inpublic co-educational schools in North Senatorial District, Benue State, Nigeria. The sample of the study comprised 83 SSIII students randomly sampled from two intact classes randomly selected from public co-educational schools in North Senatorial District, Benue State, Nigeria. The sample of the study comprised 83 SSIII students randomly sampled from two intact classes randomly selected from public co-educational schools in North Senatorial District, Benue State, Nigeria. Experimental group (n=38) was taught using scaffolding instructional strategy and control group (n=45) was taught using traditional method.

Three instruments were employed for data collection; they are: SPM, CSC and GAT. Standard Progressive Matrices (SPM) by Raven, Raven & Court (2000) to measure the intelligence levels of the students. The Cognitive Style Checklist (CSC) was adapted Robert Wyss (2002) CSC, it consists of 10 simple statements from which subjects in the research were to indicate the ones applicable to them. The checklist was used to categorize students based on their cognitive styles. It was divided into two sub-statements. Sub-statement A represents the characteristics of the Field Independent (FI) while sub-statement B represents those of Field Dependent (FD). The Genetics Achievement Test (GAT) is a 30 multiple choice items with 5-options A-E achievement test drawn from 2015-2019 past WAEC questions to measure students' achievement in Genetics. The reliability coefficient of SPM and CSC were determined through test-retest and the reliability coefficient of 0.79 and 0.76 were obtained. The reliability of GAT was determined using Kuder-Richardson formula 20 (KR₂₀) and the reliability coefficient of 0.80 was obtained.

After the selection of sample, the experiment was conducted in five phases. Firstly, CSC was administered to all groups to assess the cognitive styles of the students. Secondly, SPM was administered in the groups inorder to assess intelligence level of the students. The grouping of intelligence levels was done to create two levels i.e. high and low. Some additional sample was taken to equalize the groups. Thirdly, pre-test was administered to the students of all groups. The answer-sheets were scored with the help of scoring keys. Time limit for the test was one hour. Fourthly, treatment to experimental groups was given with scaffolding instructional strategy and to control group with traditional method of teaching. Five lessons covering the decided content were taught by the researchers. The experiment lasted for five weeks. Fifthly, at the end of the experiment, post-test was administered to the participants in

all the groups. Answer-sheets were scored and the gain scores were obtained for each participant by subtracting pretest score from post-test score. The independent variable instructional treatment was studied at two levels viz; instructions with scaffolding and traditional method of teaching. The variable cognitive styles were studied at two levels i.e. field independent and field dependent. The variable intelligence was studied at two levels i.e. high and low intelligence. The main dependent variable was 'achievement gain' which was calculated as the difference in post-test and pre-test scores for each student. Descriptive statistical techniques of mean and standard deviation, Kolmogorov– Smirnov test (K-S test) was used to ascertain the normality of the distribution of achievement scores. An Analysis of Variance $(2 \times 2 \times 2)$ was employed on the scores of the students to test the hypothesis at 0.05 level of significance.

Analysis and Interpretation of the Results:-

Research Questions:

Means and SDs for achievement scores with respect to field independent and field dependent, high & low intelligence and total scores of experimental and control groups have been presented inTable1

Variable		Experimental Group			Control Group		
		Ν	Mean	SD	Ν	Mean	SD
Field Independent	High Intelligence	10	16.51	1.28	10	13.33	1.15
	Low Intelligence	13	15.92	1.22	10	12.41	1.11
Field Dependence	High Intelligence	8	16.32	1.43	12	13.15	1.04
	Low Intelligence	7	14.87	1.46	13	12.17	0.97
	Total	38			45		

Table1:- Means and Standard Deviations of Scores for the different subgroups.

Table 1 shows that in the FI category for the experimental group, the students with high intelligence had a mean score of 16.51 and a SD of 1.28, those of low intelligence had a mean score of 15.92 and SD of 1.22. For the control group, the students with high intelligence had a mean score of 13.33 and a SD of 1.15, those of low intelligence had a mean score of 12.41 and SD of 1.11. In the FD category for the experimental group, the students with high intelligence had a SD of 1.43, those of low intelligence had a mean score of 14.87 and SD of 1.46. For the control group, the students with high intelligence had a SD of 1.40, those of low intelligence had a mean score of 13.15 and a SD of 1.40, those of low intelligence had a mean score of 12.17 and SD of 0.97

Testing Hypotheses:

The means of different sub-groups, sum of squares, degree of freedom, mean sum of squares and F-ratio have been presented in Table 2.

Sourceofvariance	Df	Sumofsquares	Meansquarevariance	F-ratio
Methods (A)	1	56.43331	56.41	10.19*
CognitiveStyles(B)	1	1.11	1.11	1.1
Intelligence C	1	37.81	37.81	5.2*
SSwithinconditions	80	551.80	8.28	
Total	83			

Table 2:- Two-way ANOVA for the Different Sub Groups.

Teaching Methods (A):

Table 2 revealed that the F-ratio for difference in mean gain scores of the group instructions with scaffolding and the group taught with traditional method is 10.19, which in comparison to the table value is found to be significant at the 0.05 level of significance. It shows that the groups were different beyond the contribution of chance and achievement with instructions with scaffolding strategy is significantly higher than that in traditional method of teaching. Hence, the hypothesis is rejected. The result indicates that the achievement of group taught using scaffolding instructional strategy has been found to be significantly higher than that of the traditional method of teaching.

Cognitive Styles (B):

Table 2 revealed that the F-ratio for difference of mean scores of the two groups of cognitive styles is 1.16, which in comparison to the table value is found not significant even at 0.05 level of significance. Hence, the null hypothesis is

rejected. The result indicates that there was a significant difference between the mean gain scores of the field independent and field dependent groups. Thus the observed difference is not attributed to the matter of chance.

Intelligence (C):

Table 2 s h o w s that the F-ratio for difference in means of intelligence levels is 5.2, which in comparison to the table was found significant at 0.05 level of significance. The result indicate that the achievement of high intelligence group is significantly higher when compared to group of low intelligence. Hence, the null hypothesis is rejected at 0.05 level of significance.

Discussion:-

The findings of this study revealed that the achievement of the group using scaffolding instructional strategy was found to be significantly higher than the group taught using traditional method of teaching. This finding is in agreement with the findings of Joda (2019); Panhdu (2018); Ibritam, Udofia, and Onweh (2015); Casem (2013); Olatubosun (2013); Akani (2015); Uduafemhe (2015) and Adamu (2017) who in their different researches asserted that instructional scaffolding strategy has a better effect on academic achievement. Also the findings revealed that the difference of achievement was significant at two levels of cognitive styles. This is in contrast with the findings of Musa and Samuel, (2019), Samuel and Musa (2019), Agu and Samuel (2019), Panddu (2018) Idika, (2017), Okoye, (2016) Agboghoroma, (2015), Owoduni, Sanni, Nwokolo and Igwe, (2016), Ezeugwu, Nji, Anyaugbunam, Enyi and Eneja, (2016), Bassey, Umoren and Udida, (2013), in their various researches reported that there is a difference between the mean achievement of Science and Mathematics students with analytical (FI) cognitive styles and those with relational and inferential (FD) cognitive styles while Ndirika (2013), opined that ability levels have no significant effect on the achievement of students.

It was also revealed that the achievement gain score of high intelligence group were significantly higher in comparison to low intelligence group. This is in agreement with the findings of Panddu (2018) who found out that the achievement gain scores of the group with high intelligence is higher than the low intelligent group when taught Science using scaffolding instructional strategy achievementin Science in relation to cognitive styles and intelligence. The reason for the achievement gain in the scaffolding group could be because of the support which may include resources, a compelling task, templates, and guides, guidance on the development of cognitive and social skills. Which help to facilitate the students' ability to build on prior knowledge and internalize new information.

Conclusion:-

The findings of this study revealed that the achievement of the group using scaffolding instructional strategy was found to be significantly higher than the group taught using traditional method of teaching. Also the findings revealed that the difference of achievement was significant at two levels of cognitive styles. It was also revealed that the achievement gain score of high intelligence group were significantly higher in comparison to low intelligence group. These results therefore show that scaffolding instructional strategy is a workable strategy for teaching Genetics.

Recommendation:-

Based on the findings of the study it was recommended that:

1. Scaffolding instructional strategy should be used by Biology teachers in the teaching Genetics.

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