INFLUENCE OF LEARNING STYLES AND TEACHING STRATEGIES ON STUDENTS' ACHIEVEMENT IN BIOLOGY

Voice of Research
Vol. 1 Issue 4,
March 2013
ISSN No. 2277-7733

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Abstract

This study investigated the effect of learning styles (active/reflective, sensing/intuitive, visual/verbal, and sequential/ global) and teaching strategies (guided inquiry, demonstration and lecture) on students' achievement in biology. Three research questions and three null hypotheses were formulated to guide the study. Two hundred and forty (240) Senior Secondary Two (SSII) biology students, comprising of one hundred and thirty six (136) females and one hundred and four (104) males were randomly drawn from six (6) Secondary Schools in Uyo Metropolis. A non-randomized control group pretest-posttest design was used for the study. Two research instruments used in gathering data for the study include: Biology Achievement Test (BAT) and Index of Learning Style Questionnaire (ILSQ). Pearson Product moment correlation was used to establish the reliability coefficient for Biology Achievement Test which stood at 0.86 Analysis of covariance (ANCOVA), Multiple Classification Analysis (MCA) and Scheffe multiple comparison test were the statistics used to analyse the data. From the findings, a significant effect was found to exist in the academic achievement of biology students taught with guided-inquiry considering their learning styles.

Keywords : *learning style, teaching strategy, achievement, biology.*

A shift from the traditional to a progressive mode of education had led to an increased interest in learners' individual differences. The new paradigm is student-centered, based on inclusiveness, cooperative learning and encouraged diversity (Zywno, 2002).

An increasing amount of research in the past years points out that the interactive process between individual student and the teacher is very important in determining the nature and quality of learning and development that result from instruction (Nwagbo, 2001). Some researchers have taken the position that it is the teaching method and not the teacher that is the key to the learning of science. It is believed that most effective learning takes place when the interactive process is one that is best suited to the individual students in terms of learning styles (Zywno, 2002).

Learning styles research has been applied at an ever-increasing rate to the problems of education (Doebler & Eke, 1979). Laxton & Murel (1987) thus suggesting that learning styles could be an extremely important element in the move to improve curricula and teaching process in school.

Anderson & Adams (1992) indicated that more attention than ever was being focused on how to meet the challenges of increased diversity in the classroom. They argued that one of the most significant challenges instructors face is to be tolerant and perceptive enough to recognize learning differences among their students.

According to Archibong (1999), the interest which students show in science subjects and the mastery they demonstrate on completion of a course of study depend on the teaching methods. Unfortunately, inspite of the much focus on teaching strategies in science, students' performance in science subjects have continued to record a persistent and depressing downward trend (Inyang, 1993). Several factors have been advanced as affecting students achievement, these include the students factors, teachers factors, societal factors, governmental infrastructural problem, language problem, instructional strategies employed by the teacher (Ali, 1984; Chacko, 1987); and recently students learning styles (Felder, 2002).

To overcome these problems, there is need to strive for a balance of effective teaching strategies such as guided-inquiry, demonstration and lecture to students' individual learning styles (Active/Reflective, Sensing/ Intuitive, Visual/Verbal, and Sequential/Global).

If the balancing is achieved, it is hoped that all students will be taught in a manner they prefer which will lead to an increased comfort level to learn, and high achievement.

It is against this background that the researcher seeks to investigate the influence of learning styles and teaching strategies on students' achievement in biology.

Purpose of the Study

Specifically, the study is designed to achieve the following objectives:

To determine the effect of teaching strategies (guided-inquiry, demonstration and lecture) on students' achievement in biology based on different learning styles(Sensing/Intuitive,Active/Reflective,Visual/Verbal, Sequential/Global).

To examine the difference in achievement in Biology by students with different leaning styles (Sensing/Intuitive,

Active/Reflective, Visual/Verbal and Sequencing/Global) taught using different teaching strategies (guided-inquiring, demonstration and lecture strategies).

To determine the influence of gender on Biology Achievement by students taught using demonstration, guided-inquiry and lecture teaching strategies with different learning styles,

Research Questions

This study was guided by the following research questions:

What is the influence of teaching strategies (guided-inquiry, demonstration and lecture) on students' achievement in biology based on different learning styles?(Sensing/Intuitive,Active/Reflective,Visual/Verbal, Sequential/Global).

What is the difference in achievement in biology by students with different learning styles (Sensing/Intuitive, Active/Reflective, Visual/Verbal and Sequential/Global) taught using (i) guided-inquiry (ii) demonstration (iii) lecture teaching strategies?

What is the influence of gender on achievement in biology by students' with different learning styles when taught using guided-inquiry, demonstration and lecture teaching strategies.

Research Hypotheses

The following research hypotheses were formulated to guide this study and were tested at 0.05 level of significance

There is no significant effect of teaching strategies (guided-inquiry, demonstration and lecture) on students achievement in biology based on different learning styles (Sensing/Intuitive, Active/Reflective, Visual/Verbal and Sequential/Global).

There is no significant difference in students achievement score in biology with different learning styles (Sensing/ Intuitive, Active/Reflective, Visual/Verbal and Sequential / Global) taught by difference teaching strategies: (i) guided-inquiry, (ii) demonstration and (iii) lecture teaching strategies.

There is no significant influence of gender on students' achievement in biology with different learning styles when taught using (i) guided-inquiry, (ii) demonstration and (iii) lecture teaching strategies.

Definition of Terms

Learning Styles: This means different approaches or ways of learning by the students as categorized by Felder and Solomon: Visual/Verbal, Active/Reflective, Sensing/ Intuitive, Sequential/Global.

Visual Learners: They get information from visual images (pictures, diagrams, graphs, demonstrative) than from verbal materials. They need to see the teacher's physically and his facial expression to fully understand the lesson.

Verbal Learners: These are learners who learn best through verbal lectures, discussion and listening to what others have to say. They get more out of written and spoken words.

Active Learners: These are learners who understand the lesson best by participating in it.

Reflective Learners: These are learners who understand lesson best by thinking about it quietly. They prefer to work alone.

Sensing Learners: Sensing learners like learning facts. They solve problem by well established methods but dislike complications.

Intuitive Learners: They learn best by discussing possibilities. They like innovation and dislike repetition.

Sequential Learners: Sequential learners gain understanding in linear steps. They go through logical stepwise path in finding solutions.

Global Learners: Global learners learn in large jumps. They solve complex problems quickly once they have grasp of the big picture.

Teaching Strategies: These are the broad or several ways in which knowledge, contents, concepts, skills, competencies, values and attitudes are inculcated in a teaching-learning setting through the guidance of a teacher. The ultimate goal being to accomplish the set objectives of a given teaching strategy. In this work, teaching strategies include guided-inquiry, lecture and demonstration.

Guided-Inquiry: This is student-centred activity, oriented teaching strategy in which the teacher directs students through problem-solving approach to discover answers to instructional topic at hand.

Lecture Method: It involves a one-way communication pattern in which the teacher is the dominant figure and students' participation is virtually non-existent, rather they listen, ask questions and take notes.

Demonstration Method: This involves the teacher or the students doing activities in front of the class and explaining as the activity progresses.

Research Design

The research design adopted for this study was a non-randomized control group pretest posttest design.

Area of Study: This study was conducted in Uyo Local Government Area of Akwa Ibom State, Nigeria.

Population: The population of the study was made up of all the senior secondary two (SS2) Biology students for the 2008/2009 session. The size of the population was two thousand two hundred and forty-five students. (2,245)

Sampling and Sampling Technique: A total of two hundred and forty (240) Senior Secondary Two (SS2) biology students took part in the study. This was made up of one hundred and four (104) male and one hundred and thirty

six (136) female students. A purposive sampling technique was used to select six (6) schools from the target population.

The instruments used in gathering data for the study were: Biology Achievement Test (BAT) and Index of Learning Styles Questionnaire (ILSQ) and the lesson packages were Guided-Inquiry Teaching Package (GITP), Lecture Method Teaching Package (LMTP) and Demonstration Teaching Package (DTP).

Biology Achievement Test (BAT)

A total of fifty (50) multiple choice items were constructed on the concept of respiratory system in man by the researcher. Each item had four (4) options (A-D) with only one correct answer. The test was used to determine the achievement of students with different learning styles on the concept of respiration in man when taught with three teaching strategies (guided-inquiry, demonstration and lecture).

Index of Learning Styles Questionaire (ILSQ)

The index of learning styles questionaire as adapted from Solomon and Felder (2004). It consisted of forty-four (44) items with options A&B. Changes were made in some of the questionaire items to reflect the cultural background of the students, thus aiding a clearer understanding of each questions and the options provided. The students were required to tick the options that apply to their learning mode. The questionaire was used to determine students' individual learning style.

Validation of Instrument

The instruments were face and content validated by two secondary school biology teachers and a senior lecturer in the Department of Psychology who specializes in test and measurement in the University of Uyo. The validators were required to look the appropriateness of the items in the instruments by providing correct responses to the test items.

Reliability of Instrument

To further strengthen the validity of the instrument, the fifty (50) multiple choice BAT items were administered to a trial testing group of fifty (50) students who were not part of the main study but were found to be equivalent in all aspects to the students' in the study. Pearson Product Moment Correlation Coefficient was used for the analysis and the result showed a reliability coefficient of 0.86.

Scoring: Each correctly answered question of the Biology Achievement Test (BAT) was scored two (2) marks. The total scores for the fifty (50) questions was 100%. a

On the ILSQ instrument, students who responded to items numbering 1,9,17,25,33,41,49,57,63,75, and 81 and were categorized as active learners. Students who ticked items numbering 2,10,18,26,34,40,50,58,64,76, and 82 were categorized as reflective learners; similarly students' who ticked items numbering 3,11,19,27,35,43,51,59,67,75, and 83 were categorized as sensing learners, for those who ticked items numbering 4,12,20,28,36,44,52,60,68,76, and 84 were categorized as intuitive learners, those who ticked items numbering 5,13,21,29,37,45,53,61,69,77, and 85 were categorized as visual learners, those who ticked items numbering 6,14,22,30,38,46,54,62,70,78 and 86 were categorized as sequential learners. Students who ticked items numbering 8,16,24,32,40,48,56,64,72,80, and 88 were equally categorized as global learners.

Research Procedure

Biology teachers in the six (6) schools were used as research assistants. They were briefed on the administration of the questionnaire on learning style. They were also exposed to the techniques of the three teaching strategies for three (3) days.

Pretest was given to all the senior secondary two (SS2) biology students in the six (6) schools.

Students in their intact classes of two (2) schools were taught the concept of respiration in man using the guided-inquiry teaching strategy

Students in their intact classes of another two (2) schools were taught the same concept using the demonstration method.

Also students in another two (2) schools in their intact classes were taught the same concept using the lecture method and this group serves as the control group.

Index of learning style questionnaire was given to all the students in the six (6) schools.

The treatment lasted for four (4) weeks of two (2) periods per week.

At the expiration of the treatment period, a posttest was given to the students which lasted for 1½ hours

The students were assigned numbers which they wrote on the index of learning style questionaire, pretest and posttest scripts for easy identification.

The collection of the index of learning style questionnaire and the posttest scripts was done personally by the researcher.

Method of Data Analysis

Data generated were analyzed using analysis of covariance (ANCOVA). All hypotheses were tested at 0.05 level of significance.

Results and Discussion

The results of the analysis of data are as presented in the following tables

Hypotheses Testing

There is no significant effect of teaching strategies (guided-inquiry, demonstration and lecture) on achievement in biology of students with different learning styles.

Table 1: 4 X 3 Factorial Analysis of Covariance (ANCOVA) of Achievement Scores by Students of Different Learning Styles Taught with Different Teaching Strategies.

Source of Variation	Sum of Square	Df	Mean Square	F.Cal	P≤ 0.05	Decision
Covariance pretest	128.41	1	128.42	6.26	0.01	*
Main effects	7697.73	5	1539.55	75.02	.00	*
TESG	6580.80	2	3290.34	160.30	.00	*
LRSY	1065.32	3	35.11	17.00	.00	*
2-way Interaction						
TESG X LRSY	208.48	6	34.75	1.69	.00	NS
Explained	135334.63	12	1127.89	54.96	.00	*
Residual	4658.71	227	20.53			
Total	18193.33	239	76.12			

NOTE : * = Significant at P≤0.05

NS = Not significant at P≤ 0.05

TESG = Teaching Strategies LRSY = Learning Styles

Table 2 : Multiple Classification Analysis (MCA) of the achievement Scores of Students with Different Learning Styles Taught Using Guided-Inquiry, Demonstration and lecture Teaching Strategies

Grand Mean = 68.17 Variable and Covariates	N	Unadjusted		Adjusted for Independent	
Variable + Category		Dev'n	Eta	Dev'n	Eta
TEACHING STRATEGIES			60		61
Guided Inquiry	88	6.06		6.10	
Demonstration	72	-0.14		-0.21	
Lecture	80	-6.54		-6.52	
LEARNING STYLES			.25		24
Sensing/Intuitive(SI)	65	1.13		1.15	
Visual/Verbal (VV)	56	-3.92	-3.70		
Active/Reflective (AR)	60	1.23	1.86		
Sequential/Global (SG)	59	1.22	0.35		
Multiple R. =	.66				
Multiple R. Square =	.43				

Table 1 shows that the main effect was significant at Pd" 0.05 alpha level, therefore the null hypothesis which stated that there is no significant effect of teaching strategies (guided-inquiry, demonstration and lecture) on students' achievement in biology based on their learning styles was rejected. This implies that the three methods of teaching differ significantly in their enhancement of the achievement of biology students with different learning styles.

Consequent upon the observed difference in the teaching strategies, Multiple Classification Analysis (MCA) was considered to determine the variance of the dependent variable (achievement) in biology that is attributed to the influence of the independent variable (teaching strategies) considering their learning styles as shown in Table 2.

As shown in Table 2, the multiple regression index (R) was .66 while the multiple regression squared index (R^2) was 0.43. This implies that 43% of the total variance in students' achievement in biology is attributable to the influence of teaching strategies and learning styles.

To find the direction of significance, the achievement scores were subjected to Scheffe multiple comparison test for a post hoc analysis as shown in Table 3.

Table 3 shows that the mean difference between guided inquiry and demonstration was 6.20, between guided inquiry and lecture method was 12.60, and between demonstration and lecture was 6.40. This implies that guided inquiry was the most effective in facilitating students' achievement in biology considering their learning styles.

Hypothesis Two

There is no significant difference in students' achievement in biology with different learning styles (Sensing/Intuitive, Visual/Verbal, Active/Reflective and Sequential/Global) taught using: (i) guided-inquiry (ii) demonstration (iii) lecture.

The analysis of hypothesis two is presented on tables 4, 5 and 6 respectively.

Table 4 shows that the learning styles main effect was significant at P d" 0.05, therefore the null hypothesis stating a non significant difference in the achievement of biology students with different learning styles taught using guided-inquiry was rejected. This means that the four pairs of learning styles differ significantly in their enhancement of the achievement of biology students after

Table 3: Result of Scheffe's Post Hoc Test for Multiple Comparison of Teaching Strategies on Students' Achievement in Biology

(I) Teaching Strategies	(I) Teaching Strategies	Mean Difference (I-J)	Std Error	Sig	95% Confidence Lower Bound	Interval Upper Bound
Inquiry	Demonstration	6.20*	.72	.000	4.43	7.97
	Lecture	12.60*	.70	.000	10.88	
Demonstration	Inquiry	-6.20*	.72	.000	-7.97	-4.43
	Lecture	-6.40*	.74	.000	4.59	8.22
Lecture	Inquiry	-12.60*	.70	.000	-14.33	-10.88
	Demonstration	-6.40*	.74	.000	-8.22	-4.59

***= The Mean difference is significant at 0.05 level**

Table 4: one-way Analysis of Covariance (ANCOVA) of achievement of biology students with different learning styles taught using guided-inquiry.

Source of Variation	Sum of squares	Df	Mean square	F.Cal	pd≤0.05	Decision
Covariate pretest	110.95	1	110.95	3.66	.06	NS
Main effect	4393.69	3	1464.23	48.31	.00	*
Explained	4503.63	4	1125.91	37.15	.00	*
Residual	2515.82	83	30.31			
Total	7019.46	87	80.68			

*= Significant at Pd" 0.05; NS = Not significant at Pd" 0.05,

being taught using guided-inquiry. However, consequent upon the existence of significant difference in the learning styles, Multiple Classification Analysis (MCA) was considered to determine the influence of the independent variable (learning styles) as shown in table 5.

Table 5: Multiple Classification Analysis (MCA) of the Achievement scores of Students with Different Learning Styles Taught with Guided Inquiry

Grand Mean = 74.23	N	Unadjusted		Adjusted for Independent Variable and Covariates	
Variable + Category		Dev'n	Eta	Dev'n	Eta
LEARNING STYLES			.80		.80
Sensing/Intuitive (SI)	23	9.08		9.07	
Visual/Verbal (VV)	20	-10.43		-10.70	
Active/Reflective (AR)	18	3.77		3.69	
Sequential/Global (SG)	27	-2.52		-2.49	
Multiple R. =	.80				
Multiple R. Square =	.64				

As shown in Table 5, the multiple regression index (R) was .80, while the multiple regression squared index (R^2) was .64. This means that 64% of the total variance in the achievement of students in biology is attributed to the influence of different learning styles of students when taught with guided inquiry.

To find the direction of significance, the achievement scores were subjected to Scheffe multiple comparison test for a post hoc analysis as shown in Table 6.

Where: SI = Sensing/Intuitive
VV = Visual/Verbal
AR = Active/Reflective
SG = Sequential/Global

As shown in table 6, the mean difference between Sensing/Intuitive and Visual/Verbal was 19.50; between Sensing/Intuitive and Active/Reflective was 5.30; between Sensing/Intuitive and Sequential/Global was 11.60; between Active/Reflective and Visual/Verbal was 14.20; between Active/Reflective and Sequential/Global was 6.30; and between Sequential/Global and Visual/Verbal was 7.90. This implies that Sensing/Intuitive learning style was the most effective in facilitating students' achievement in biology when taught with guided inquiry. This was seconded by Active/Reflective, followed by Sequential/ Global while Visual/Verbal learning styles was the least effective in facilitating students' achievement in biology when taught with guided Inquiry. Hence, guided inquiry is the most effective teaching strategy for biology students with Sensing/Intuitive learning style.

Table 6: Result of Scheffe's Post Hoc Test for Multiple Comparison of Learning Styles on Students' Achievement in Biology Taught Using Guided Inquiry.

(I) Teaching Strategies	(I) Teaching Strategies	Mean Difference (I-J)	Std Error	Sig	95% Confidence Interval Lower Bound	Upper Bound
SI	VV	19.50*	1.68	.000	14.73	24.28
	AR	5.30*	1.72	.129	0.39	10.22
	SG	11.60*	1.55	.000	7.17	16.04
VV	SI	-19.50*	1.67	.000	-24.28	-14.73
	AR	-14.20*	1.78	.000	-19.28	9.12
	SG	-7.90*	1.62	.000	-12.52	-3.29
AR	SI	-5.30*	1.72	.129	-10.22	-0.39
	VV	-14.20*	1.78	.000	9.12	19.28
	SG	6.30*	1.66	.004	1.54	11.05
SG	SI	-11.60*	1.55	.000	-16.04	-7.17
	VV	7.90*	1.62	.000	3.29	12.52
	AR	-6.30*	1.68	.004	-11.05	-1.54

*= The Mean difference is significant at 0.05 level

Table 7: One-way Analysis of Covariance (ANCOVA) of Students' Achievement in Biology with Different Learning Styles Taught Using Demonstration Method.

Source of Variation	Sum of Square	Df	Mean Square	F.Cal	P< 0.05	Decision
Covariance	1.49	1	1.49	0.08	.78	NS
Pretest	1417.81	3	472.60	25.36	.00	*
Main effects	1419.30	4	354.82	19.04	.00	*
Explained	1248.65	67	18.64			
Residual	2667.95	71	37.58			

Table 7 shows that the learning styles main effect was significant at P?.05, therefore the null hypothesis which stated that there is no significant difference in the achievement of biology students with different learning styles taught using demonstration method was rejected. This means that the four types of learning styles differ significantly in their enhancement of the achievement of biology students after being taught using demonstration method. Consequently upon the existence of significant differences in the learning styles, Multiple Classification Analysis (MCA) was considered to determine the variance of the dependent variable (achievement) in biology that is attributed to the influence of the independent variable (learning styles) as shown in Table 8.

As shown in Table 8, the multiple regression (R) was .73 while the multiple regression squared index (R2) was .53. This means that the 53% of the total variance in the achievement of students in biology is attributable to the influence of different learning styles when taught with demonstration strategy. To find the direction of

Table 8: Multiple Classification Analysis (MCA) of the Achievement of Students with Different Learning Styles Taught with Demonstration Method

Grand Mean = 74.23	N	Unadjusted		Adjusted for Independent Variable and Covariates	
Variable + Category		Dev'n	Eta	Dev'n	Eta
LEARNING STYLES			.73		.73
Sensing/Intuitive (SI)	21	-1.93		9.07	
Visual/Verbal (VV)	16	-5.78		-5.79	
Active/Reflective (AR)	19	1.13		1.08	
Sequential/Global (SG)	16	6.97		7.00	
Multiple R. =	.73				
Multiple R. Square =	.53				

significance, the achievement scores were subjected to Scheffe multiple comparison test for a post hoc analysis as shows in table 9.

As shown in Table 9, the mean difference between sequential/global and sensing/intuitive was 8.91; between sequential/global and visual/verbal was 12.75; between sequential/global and active/reflective was 5.84; between sensing/intuitive and visual/verbal was 3.85; between active/reflective and visual/verbal was 6.91; and between active/reflective and sensing/intuitive was 3.06. However, there was no significant difference between sensing/ intuitive and visual/verbal and also between active/ reflective and sensing/intuitive. The results show that sequential/global learning style was the most effective in facilitating students' achievement in biology when taught

Table 9: Result of Scheffe's Post Hoc Test for Multiple Comparison of Learning Styles on Students' Achievement in Biology Taught Using Demonstration Method.

(I) Teaching Strategies	(I) Teaching Strategies	Mean Difference (I-J)	Std Error	Sig	95% Confidence Interval Lower Bound	Upper Bound
SI	VV	3.85*	1.43	.073	-0.24	7.93
	AR	-3.06*	1.36	.177	-6.96	0.83
	SG	-8.90*	1.43	.000	-12.99	4.82
VV	SI	-3.85*	1.43	.073	-7.93	0.24
	AR	-6.91*	1.46	.000	-11.08	-2.73
	SG	-12.75*	1.52	.000	-17.10	-8.40
AR	SI	3.06*	1.36	.177	-0.83	-6.96
	VV	6.91*	1.46	.000	2.73	11.08
	SG	-5.84*	1.46	.002	-10.02	-1.67
SG	SI	8.91*	1.43	.000	4.82	12.90
	VV	12.75*	1.52	.000	8.40	17.10
	AR	5.84*	1.46	.002	1.67	10.02

*= The Mean difference is significant at 0.05 level

Where: SI = Sensing/Intuitive
VV = Visual/Verbal
AR = Active/Reflective
SG = Sequential/Global

with demonstration. This was followed by active/ reflective, followed by sensing/intuitive while visual/ verbal learning style was the least effective in facilitating students, achievement in biology when taught with demonstration teaching strategy.

Hence, demonstration is the most effective teaching strategy for biology students with sequential/global learning style.

Table 10: One-way Analysis of Covariance (ANCOVA) of Achievement of Biology Students with Different Learning Styles Taught Using Lecture Strategy.

Source of Variation	Sum of squares	Df	Mean square	F.Cal	p≤0.05	Decision
Covariate pretest	26.82	1	26.82	2.25	.14	NS
Main effect	929.30	3	309.77	26.03	.00	*
Explained	956.12	4	239.03	20.08	.00	*
Residual	892.63	75	11.90			
Total	1848.75	79	23.40			

Table 10 shows that the learning styles main effect was significant at P?0.05, therefore the null hypothesis which stated that there is no significant difference in the achievement of biology students with different learning styles taught using lecture strategy was rejected. This means that the four pairs of learning styles differ significantly in their enhancement of the achievement of biology students taught using lecture strategy. However, consequent upon the existence of significant difference in the learning styles, Multiple Classification Analysis (MCA) was considered to determine the variance of dependent variable (achievement) in biology that is the attributable to the influence of the independent variable (learning styles) as shown in Table 11.

As shown in Table 11, the multiple regression index (R) was .72 while the multiple regression squared index (R2) was .52. This means that 52% of the total variance in the achievement of students in biology is attributable to the influence of different learning styles of students when taught using lecture strategy.

To find the direction of significance, the achievement scores were subjected to Scheffe multiple comparison test for a post hoc analysis as shown in Table 12.

Table 11: Multiple Classification Analysis (MCA) of the Achievement Scores of Students with Different Learning Styles Taught with Lecture Strategy

Grand Mean = 74.23	N	Unadjusted		Adjusted for Independent Variable and Covariates	
Variable + Category		Dev'n	Eta	Dev'n	Eta
LEARNING STYLES			.71		.71
Sensing/Intuitive (SI)	21	-4.48		-4.50	
Visual/Verbal (VV)	16	4.67		4.63	
Active/Reflective (AR)	19	1.24		1.22	
Sequential/Global (SG)	16	-1.75		-1.63	
Multiple R. =	.72				
Multiple R. Square =	.52				

Where: SI = Sensing/Intuitive
VV = Visual/Verbal
AR = Active/Reflective
SG = Sequential/Global

As shown in Table 12, the mean difference between visual/ verbal and sensing/intuitive was 9.16; between visual/ verbal and active/reflective was 3.43; between visual/ verbal and sequential/global was 6.43; between active/ reflective and sequential/global was 3.00; between active/ reflective and sensing/intuitive was 5.73, and between sequential/global and sensing/intuitive was 2.73. However, there was no significant difference between sequential/ global and sensing/intuitive and also between active/

Table 12: Results of Scheffe's Post Hoc Test for Multiple Comparison of Learning Styles on Students' Achievement In Biology Taught Using Lecture Strategy

(I) Teaching Strategies	(I) Teaching Strategies	Mean Difference (I-J)	Std Error	Sig	95% Confidence Interval Lower Bound	Upper Bound
SI	VV	-9.16*	1.08	.000	-12.24	-6.07
	AR	-5.73*	1.04	.000	-8.71	-2.75
	SG	-2.73*	1.15	.037	-6.01	0.54
VV	SI	9.16*	1.08	.000	6.07	12.24
	AR	3.43*	1.06	.019	0.41	6.45
	SG	6.43*	1.16	.000	3.12	9.74
AR	SI	5.73*	1.04	.000	2.75	8.71
	VV	-3.43*	1.06	.019	-6.45	-0.41
	SG	3.00*	1.12	.077	-0.22	6.21
SG	SI	2.73*	1.15	.037	-0.54	6.01
	VV	-6.43*	1.16	.000	-9.74	-3.12
	AR	-3.00*	1.12	.077	-6.21	0.22

*= The Mean difference is significant at 0.05 level

reflective and sequential/global. The results showed that visual/verbal learning styles was the most effective in facilitating students' achievement in biology when taught with lecture strategy. This was seconded by active/ reflective, followed by sequential/global while sensing/ intuitive was seen to be the least effective in facilitating students' achievement in biology when taught with lecturer strategy. Hence, lecture strategy is the most effective teaching strategy for biology students with visual/verbal learning style.

Hypothesis Three

There is no significant influence of gender on achievement in biology by students with different learning styles when taught using guided-inquiry, demonstration and lecture teaching strategies.

The above table presents the obtained F-value effects of three variables (teaching strategies, learning style and gender as 0.43. Hence the result was not significant at $P \leq 0.05$. The result therefore means that there is not significant influence of gender on biology students' achievement with different learning styles when taught using guided-inquiry, demonstration and lecture teaching strategies.

Conclusion

On the basis of the findings in this study, the following conclusions are drawn.

Students with Sensing/Intuitive learning styles perform better when taught with guided-inquiry teaching strategy.

Demonstration teaching strategy is the most effective strategy in enhancing the achievement of students with Sequential/Global learning style.

Lecture method is most effective for students with Visual/ Verbal learning style.

There is no significant influence of gender on students' achievement when taught using guided-inquiry, demonstration, and lecture teaching strategies based on their learning style.

Recommendations

Based on the results obtained from this study, the following recommendations are made:

Educators and instructional designers need to build courses and programmes that will be of benefit to students of multiple learning styles.

Seminars, workshops and conference should be organized for teachers to familiarize and update their knowledge with the use of index of learning style questionnaire for possible use to identity students learning styles with a view to incorporating them into basic pedagogical skills during lesson delivery.

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Table 13: Three-way Analysis of Covariance of the Influence of gender on Biology Students' Achievement with Different Learning Styles when Taught Using Guided-Inquiry, Demonstration and Lecture Teaching Strategies.

Source of Variation	Sum of Square	Df	Mean square	F.Cal	P≤0.05
Main effect	14012.377	24	583.549	30.02	0.00
Pre-test	41.989	1	41.989	2.15	0.14
Teaching strategies	6152.340	2	3076.170	158.18	0.00
Learning styles	1001.027	3	33.676	17.15	0.00
Gender	189.218	1	189.218	9.73	0.00
Teaching strategy					
Gender	0.214	2	0.107	0.00	0.99
Learning styles					
Gender	80.870	3	24.957	1.38	0.24
Teaching strategy					
Learning styles X					
Gender	63.336	6	10.556	0.43	0.77
Explained	23615.021	1	23615.02	1214.57	0.00
Residual	4180.215	19.446			
Total	**18193.333**	**239**			

N/B: Significance is based on three (3) level of interaction.

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