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CAN THE LEARNING CYCLE CURRICULUM MODELS BRING SECONDARY SCHOOL STUDENTS BACK TO EXPERIMENTAL BIOLOGY?

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ABSTRACT

The study investigated the possible utility of the learning cycle instructional model in facilitating the acquisition of learning outcomes associated with experimentation in senior secondary school biology. Nine intact classes were selected by stratified random sampling technique from twenty government-owned senior secondary schools in Ika North East local government area of Delta state of Nigeria. 273 senior secondary school two (SS 2) students participated in the study. The instructional model which consisted of a Descriptive learning cycle (DLC), Hypothetico-predictive learning cycle (HPLC), and Traditional Expository approach (TEA) was the independent variable while biology learning outcome consisting of three levels (scientific reasoning skill, achievement in biology concepts, and attitude towards biology) was the dependent variable. The study lasted for eight weeks during which six treatment packages drawn from six concepts in SS 2 biology scheme were administered to three groups in a quasi-experimental setting. Data were collected using three instruments. The result showed that HPLC produced the highest learning outcome effects with attitude towards biology being most enhanced followed by scientific reasoning skills and achievement in biology concepts. This is followed by the DLC and TEA in the same order. It is hereby recommended that learning cycle models with their inherent benefit be employed in the teaching of biology.

***Keywords**: Learning cycle, instructional model, model, instructional innovation, secondary school innovation, teaching*

1. INTRODUCTION

The last quarter of the 20th century met with science educators' renewed focus on improving the quality of teaching and learning of science in schools. The determination is traceable to general dissatisfaction with the quality of science products globally. Harbison (1973) indicated the implication of a poorly developed human resource of a nation when he stated that a country that is unable to develop the skills and knowledge of its people and utilize them effectively in the national economy will be unable to develop anything else. This is the plight of most underdeveloped countries of the world today. Africa and Nigeria in particular, within the current evolution taking place in the new partnership for Africa Development (NEPAD), the National Economic empowerment and development strategy (NEEDS), and the Millennium Development Goals (MDG), have identified effective and purpose-driven science education as a pivot for rapid technological development and as a force for driving development in other sectors of national life.

The underdevelopment has been blamed on the defective and static curricula in use in schools; didactic pedagogies often employed in science implementation and obsolete content that has no relevance to modern educational needs (Ukpong 2004; Adeyemi 1996).

2. HISTORICAL AND THEORETICAL BACKGROUND

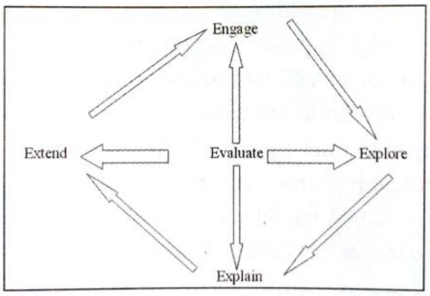
The learning cycle curriculum effort is traceable to the science curriculum improvement study (SCIS) which was a primary school science curriculum effort of the 1950s and 1960s (Atkin & Karplus 1962, Abraham 1998). The term 'learning cycle' was not however known in literature until the 1970s when it was used in the teachers' guide. Its major strong- point as a curriculum model is that content and instruction are arranged such that they progress in sequential phases, with each phase providing the needed knowledge base for the succeeding one. In addition to that, knowledge is constructed by the learner as a result of interaction with activities drawn from the environment.

The learning cycle is an inquiry-based instructional device developed with the philosophy that concrete experience and social interaction are necessary for learning (Westbrook & Rogers 1994). Science learning proves unproductive (in terms of objectives of science learning worldwide) if students do not possess an in-depth conceptual understanding of science or the ability to apply scientific concepts and principles. Hurst and Milkent (1996) argued that unless teachers begin to adopt strategies that focus on specifically desired science learning outcomes, science classroom products will remain unproductive.

The re-emergence of the learning cycle curriculum and the accompanying instructional strategies are aimed at developing problem-solving abilities as a means of facilitating high-level thinking and conceptual understanding of science curriculum concepts. The sequence of stages in the learning cycle instructional format utilizes an activity framework for driving home understanding.

Piaget's (1964) theoretical model of self-regulation provides the basis for the learning cycle. It explained the process of learning in humans as a dynamic process of equilibration consisting of successive levels of equilibrium. In Piaget's equilibrated system, an achieved equilibrium results in the need to compensate for the transformed process thereby leading to a new equilibrated situation. This psychological process as put forward by Piaget is a cyclical one. The constructivist view of the nature of science, a developmental extension of Piaget's ideas, has influenced contemporary knowledge of how individuals learn. Towbridge and Bybee (1990) and Lorsbach (2002), working within that paradigm, have presented a theoretical cyclical s E's model of the learning cycle which includes Engage, Explore, Explain, Extend and Evaluate.

FIGURE 1. Five-phase cyclical learning cycle model (from Lorshbach,2002)



Karplus (1977) proposed a model consisting of three phases of instruction in which learning science aims at the development of new reasoning patterns after the learner interacts with phenomena and the ideas of others. Sunal (1992) provided an interesting review of instructional models within the learning cycle. Some of such models that incorporate the learning cycle ideas are Driver and Oldham (1986), Osborne and Wittrock’s (1983) Generative learning model, and Hewson and Hewson (1988). Lawson, Abraham, and Renner (1989) advocated a 3-phase learning cycle after that proposed by Atkin and Karplus (1962) for the SCIS project. Good (1987), in line with the cognitive science and artificial intelligence tradition, proposed the inclusion of 'prediction' as the first phase of the learning cycle. Lavoie (1999) suggested a hypothetico-predictive phase prior to the three-phase learning cycle to emphasize hypothetico-predictive reasoning as a means of making students aware that alternative viewpoints exist and as such help learners to develop a cognitive and effective commitment to prediction. The predictive phase in Lovoie's idea is intended to direct the learner to focus on and reason scientifically around the science concept being studied. Lavoie (1999) explains that such mental exercises positively affect learners' attitudes toward the learning of science. Abraham (1998) puts the idea behind the sequence of phases in the learning cycle thus:

> *To facilitate accommodation, instruction should expose the learner to a segment of the environment that demonstrates the information to be accommodated. This should be followed by activities that help the learner accommodate the information. Finally, to organize the accommodated information, activities should be developed that help the learner see the relation between the new information and other previously learned information. (Abraham,1998;515)*

What this signifies is that humans do not just learn haphazardly. There usually exists an interaction between the human mind and the environment such that the human mind enters into an integrated accord with the knowledge that the environment houses.

3. STATEMENT OF THE PROBLEM

Since its independence in 1960, Nigeria has had changes in its educational policy. The intention has been to evolve a curriculum that will help her prepare her citizens for the challenges of development. A curriculum desired for the 21t century Nigeria must make it possible for learners to develop modern scientific skills through appropriate instructional manipulations, employ the acquired skills to access new knowledge using modern facilities, utilize the knowledge to predict, expect and recognize imminent changes and use their rational senses to formulate solutions to problems caused as a result of the change. Such problems include those connected with the economy, hunger, food supply, population explosion, new reasoning in technological circles, harnessing and management of natural resources as well as predicting and managing eventualities in natural phenomena. The learning cycle instructional model, the main focus of this study, is a curriculum developmental effort towards the achievement of modern science instructional and national objectives. This study, (a part of a larger one) is an attempt to identify the effect of two learning cycle models on biology students' achievement and attitude toward science. The following research questions were asked to guide the study.

1) What is the effect of instructional model [Descriptive Learning Cycle (DLC), Hypothetico-Predictive Learning Cycle (HPLC), and Traditional Expository Approach (TEA)] on biology students learning outcome (Scientific reasoning skills, Achievement in Biology concepts, and Attitude towards biology)?
2) Are there differences in the level of Biology Learning outcome (Scientific reasoning skills, Achievement in biology concepts, and Attitude towards biology)?
3) Does the method of instruction interact with learning outcome in biology?

4. HYPOTHESES

The following hypotheses were tested

1) There is no significant difference in the learning outcome of biology students taught with different instructional models (DLC, HPLC, and TEA)
2) There is no significant difference in biology students' attainment in learning outcome (Scientific reasoning skills, Achievement in biology concepts, and Attitude toward biology).
3) There is no significant interaction effect of method on student learning outcome

5. SAMPLING TECHNIQUE AND METHOD

Three senior secondary schools were selected from twenty secondary schools in Ika North East Local Government Area of Delta State by stratified random sampling technique. Stratification was based on school type (all-boy, all-girl, and co-educational). By this method, nine classes consisting of 273 SS11 students from three senior secondary schools were drawn and assigned to treatment groups (DLC, HPLC & TEA) by simple ballot. A pretest-posttest control group (non-equivalent group) design was adopted. The instructional model formed the independent variable while learning outcome consisting of scientific reasoning skills, achievement in biology concepts and attitude towards biology was the dependent variable. The study lasted for eight weeks. The first week of treatment was used to acquaint both subjects and assistant researchers with the principles of the study while the eighth week was used to administer post-test instruments for data collection. Six teaching units were covered during the remaining six weeks of teaching. The content of instruction was drawn from:

1) Osmosis in living tissues
2) Evidence of photosynthesis
3) Homeostasis
4) Feeding relationship in an ecosystem
5) Digestive enzymes
6) Tropical rainforest

Three intact classes were randomly assigned to each treatment group in each of the three schools. Three types of classroom procedures consisting of six planned lessons for each treatment group were used. Instruction was similar in terms of the objectives of the lesson, content and duration of the lesson, and evaluation of learning outcomes. In contrast, the HPLC procedures required that learners carry out hypothetico- predictive activities in prepared worksheets before engaging in the three-phase learning cycle. The idea of hypothetico- predictive worksheet was to prompt learners to make and produce alternative conceptions of the topic at hand as a basis for developing new or more refined and acceptable conceptions. The DLC group, on the other hand, goes straight into the learning cycle directly.

Pre-and post-test data were collected using three post-test instruments:

1) Test of achievement in Biology concepts, a 45-item multiple-choice instrument whose reliability was found by Kudder Richardson formula 21 to be 0.73. The items for the test were drawn from the six concepts taught during treatment.
2) Test of scientific reasoning skills, a 10-item test of logical reasoning in biology. Items were drawn from the content of the instruction. It tested subjects' understanding of relationships, the logic of relationships, and the drawing of conclusions from relationships. The items were modeled after

Lawson's (1992) logic task as used by Norman (1997). Kudder Richardson 21 yielded a reliability coefficient of o.40. the low-reliability coefficient is a common feature of short scales (Pallant, 2001)

3) Test of attitude towards Biology, a 29- item 5- point Likert scale instrument made up of 16 positively and 13 negatively worded items. Cronbach's alpha yielded a reliability coefficient of o.81.

6. RESULTS AND FINDINGS

The 3-way repeated measures ANOVA was employed for the statistical analysis of data and results are presented in the tables below.

TABLE1. Distribution of means of post-test Biology learning outcome by method by school type by repeated measures (Learning outcome)

		Learning outcome			
Method	**School type**	**Scientific Reasoning Skills**	**Achievement in Biology**	**Altitude towards Biology**	**Total**
DLC	Co – Ed	33.24(34)	25.62(34)	63.45(34)	40.77(102)
	All Boys	39.06 (32)	34.31(32)	74.85(32)	49.41(96)
	All Girls	38.10(21)	27.94(21)	68.90(21)	44.98(63)
	Total	36.55(87)	29.37(87)	68.96(87	44.96(261)
HPLC	Co – Ed	41.00 (30)	31.56(30)	72.00(30)	48.19(90)
	All Boys	53.85(39)	44.16(39)	79.36(39)	59.12(117)
	All Girls	73.00(10)	41.11(10)	72.62(10)	62.24(30)
	Total	51.39(79)	38.99(79)	75.71(79)	55.36(237)
TEA	Co – Ed	33.17(60)	21.56(60)	64.39(60)	39.70(180)
	All Boys	36.56(32)	29.03(32)	64.98(32)	43.52(96)
	All Girls	32.00(15)	24.59(15)	60.55(15)	39.05(45)
	Total	24.22(107)	24.22(107	64.03(107)	40.75(321)
TOTAL	Co – Ed	35.08(124)	25.09(124)	65.97(124)	42.05(372)
	All Boys	43.88(103)	36.40(103)	73.49(103)	51.26(309)
	All Girls	43.70(46)	29.71(46)	66.99(46)	46.80(138)
	Total	39.85(273)	30.13(273	68.98(273)	46.32(819)

TABLE 2. ANOVA Summary for Effects of method (treatment), School type and Repeated measures (Learning outcome) with scores of post treatment learning outcome in Biology as the dependent variable

Source	**SS**	**df.**	**MS**	**F**	**P**
Method (Treatment)	25334.55	2	12667.28	77.35	0.00
Repeated Measures (Learning Outcome)					
School Type	161158.07	2	80579.04	492.05	0.00
	10297.57	2	5148.78	31.44	0.00
Method*Repeated Measures	3480.60	4	870.15	5.31	0.00
Method*School Type	3639.78	4	909.95	5.56	0.00
Repeated Measure*School Type*					
Method	2462.28	4	615.57	3.76	0.01
	3540.11	8	442.51	2.70	0.01
School Type	129700.46	792	163.76		
Error	401812.81	818			
Corrected Total					

** P ≤ 0.05 is significant*

TABLE 3. Post hoc. Analysis of direction of significance using the Scheffe test

i Type of Treatment	j Type of Treatment	Mean difference (I – j)	Standard Error	Sig	95% confidence interval	
					Lower bound	Upper bound
DLC	HPLC	-10.40	1.15	0.00	-13.22	-7.59
	TEA	4.21	1.07	0.00	1.59	6.82
HPLC	DLC	10.40*	1.15	0.00	7.59	13.22
	TEA	14.61*	1.10	0.00	11.92	17.30
TEA	DLC	-4.21	1.07	0.00	-6.82	-1.59
	HPLC	-14.61	1.10	0.00	-17.30	-11.92

Based on observed means / Mean difference is significant at P ≤ 0.05 levels*

The F-value of instructional model effect (Table 2) was 77.35 with df (2,792), significant at 0.00 and hence significant at 0.05 level. The null hypothesis 1, that there is no significant difference in the effect of the models on the learning outcome of students was rejected. Results thus showed that the model of instruction significantly affected students' learning outcome in Biology. In order to ascertain the direction of the significance of the difference, Sheffe multiple comparisons were carried out (Table 3). It revealed a significant difference between DLC and TEA (mean difference 4.21), HPLC and DLC (mean difference 10.40), and HPLC and TEA (mean difference 14.61). The implication is that HPLC produced the highest outcome results followed by the DLC.

In determining the result of the study with respect to hypothesis two, F-value in table 1.2 was 492.05, significant at 0.00. The hypothesis of no significant difference in the type of learning outcome promoted by the instructional models was rejected. It implies that the instructional models used in this study differentially affected the students' acquisition of learning outcomes with respect to scientific reasoning, achievement in biology concepts, and attitude toward biology. Further post hoc analysis showed a significant difference between scientific reasoning skills and achievement in biology concepts (9.72) attitude toward biology and scientific reasoning skills (29.13) and attitude towards biology and achievement in Biology concepts (38.85) respectively.

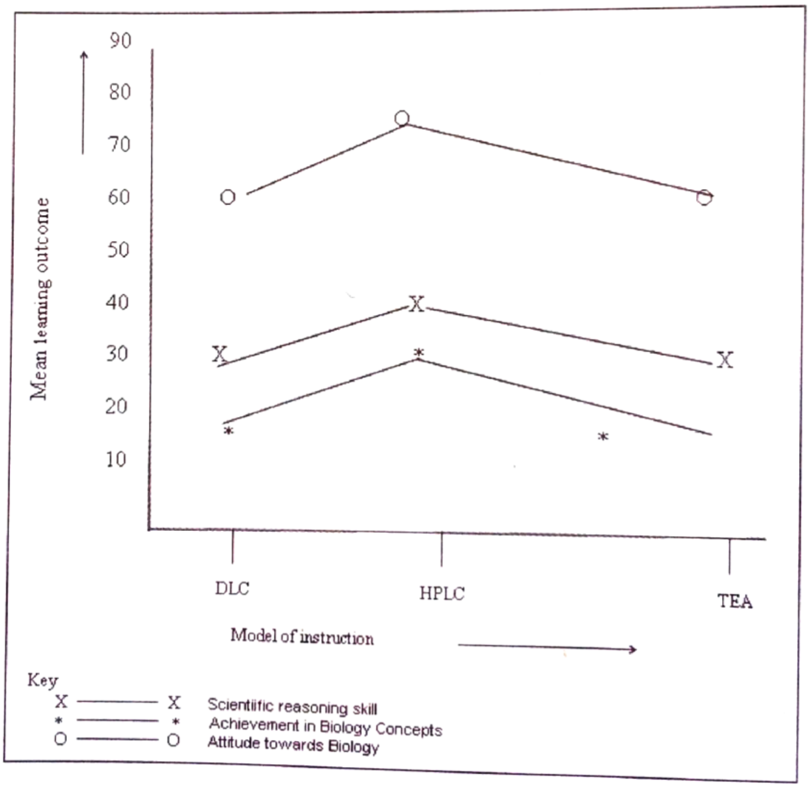
In order to identify the instructional model that was of greatest efficacy in promoting the acquisition of each level of the learning outcome, hypothesis three, which stated a no interaction effect of instructional model and learning outcome was likewise analyzed. Result showed an F - value of 5.31 (df 4,792) which is significant at 0.00 level and as such significant at 0.05 alpha level set for this study. The null hypothesis was thus rejected. The implication is that the extent or degree of acquisition of each learning outcome varied with the model of instruction. It can also be said that the effect of the instructional model is not uniform across all learning outcome levels. A graphical presentation of the models and the three levels of learning outcome is ordinal (see Figure 2.). It can therefore be adduced that across all groups of the method, scores on attitude towards biology are highest followed by scientific reasoning skills, then achievement in biology concepts after all three measures have been put in the same metric (percentage). However, the difference between scientific reasoning skills and attitude towards biology is widest in the DLC group followed by that of HPLC and TEA. The difference between achievement in biology concepts and scientific reasoning is widest in the HPLC group followed by that of DLC. In general, the difference between achievement in biology and scientific reasoning is not less than three times the difference between scientific reasoning and attitude toward biology.

Level of learning outcome

TABLE 4. Cell means of model and Learning outcome

		Scientific Reasoning skill	Achievement in Biology	Attitude towards Biology	Total
Instructional Models	DLC	16.55 (87)	29.37 (87)	68.96 (87)	44.96 (261)
	HPLC	51.39 (79)	38.99 (79)	75.71 (79)	55.31 (273)
	TEA	34.02 (107)	24.22 (107)	64.03 (107)	40.75 (321)
	Total	39.85 (273)	30.13 (27.3)	68.96 (273)	46.32 (819)

FIGURE 2. Graphical representation of the nature of models by learning outcome interaction



7. CONCLUSION

Model of instruction is a major variable that determines or affects student's learning outcome in biology. Appropriate pedagogic application boosts learning in all measures. Hypothetico-predictive learning cycle (HPLC) in this study, proved to be the most effective way to teach biology for several reasons including its affinity for drawing students into the environment and nature, its tendency to facilitate students' reasoning skills through regular mental and thought-provoking tasks and significantly improve their attitude towards the subject by hands-on participatory activities in a social learning environment. These features of the HPLC are not unconnected with the model's peculiar characteristics of harnessing students' innate characteristics of inquisitiveness, probing, drawing premature conclusions (which could be effectively managed by an efficient teacher for learning benefits) as well as predicting occurrences. The descriptive learning cycle proved better than the traditional expository approach in the teaching of biology. Its hands-on sequential teaching and learning property make it effective for improving learning outcome such as attitude of students towards learning and scientific reasoning skills. The large curriculum content of Biology, the large class size, and the difficulty associated with preparing and planning learning cycle lessons may frustrate teachers into using Expository Approach. This study has shown that it is not an effective approach to teaching biology since the subject is the study of life and the environment. Only approaches where students' own ideas are recognized, respected, and utilized tend to facilitate a high degree of complex learning outcomes such as scientific reasoning skills.

The learning cycle groups produced outstanding learning outcome compared to the TEA group. Subjects of the learning cycle model produced a consistently better grasp of both content and experimental procedures. The predictive skill, which is a desirable 'habit of mind' in science learning and the experimental science field, is a major attribute that could be harnessed in support of classroom science teaching and the promotion of science experimental adventures by learners.

It is necessary to mention here that though the study indicated no significant difference in achievement in biology concepts, literature has shown that attitude towards learning positively influences achievement in concepts but not vice versa.

8. RECOMMENDATION

It is hereby recommended that learning cycle teaching models be employed by biology teachers for their numerous benefits. The expository approach to biology teaching should only be used sparingly for clarifying facts that require further explanation. Science knowledge anchored on creative thinking is necessary for developing productive science. Curriculum developers especially in developing countries should consider the inclusion of learning cycle prototype instructional lessons in modern books and texts as motivation to teachers to utilize the model in their instructional process as well as create awareness of its use and advantages.

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