TWOWS AFRICA INTERNATIONAL JOURNAL OF SCIENCE AND TECHNOLOGY

MAIDEN EDITION

VOLUME 1 JUNE 2010

EFFECTS OF LEARNING CYCLE CURRICULUM MODELS ON MALE AND FEMALE STUDENTS' SCIENCE LEARNING: IMPLICATIONS FOR PREPARATION OF QUALITY YOUNG SCIENTISTS

***Moemeke, Clara D. and Omoifo Christy N**
*Department Of Curriculum Studies and Educational Technology
College of Education, Agbor E-Mail moemekegeorge2000@yahoo.co.uk
Department Of Educational Psychology and Curriculum Studies
Faculty Of Education, University of Benin, Benin City E-Mail
cnomoifo@yahoo.co.uk

ABSTRACT

The study is an investigation of the effect of two learning cycle curriculum models [hypothetico-predictive Learning cycle (HPLC) and Descriptive Learning Cycle (DLC)] and expository approach (TEA) on male and female students' science learning outcome. The rationale for the study among others is to determine any differential effect of the curriculum models on male and female students within the science learning environment. A quasi-experimental design (Non-equivalent group) was adopted. Two hundred and seventy-three senior secondary two students in nine intact classes who were randomly assigned to treatment groups participated in the study. These subjects were drawn from one Co-educational, one All-boys, and one All-girls school equivalent in facilities, teacher qualities, and students' initial ability. The study lasted for eight weeks at the end of which three instruments were used to collect data. They are the Test of science achievement (TSA), Test of scientific reasoning skills (TSRS), and Test of attitude towards science (TATS). Data generated were subjected to 3-way repeated measures analysis of variance. The result showed that there was a significant effect of instructional models on science students learning outcome with the HPLC proving superior and TEA least superior. School type was also found to significantly affect students learning outcome in science. All-boys school students showed the highest gains from the instructional models and the co-educational students least gain across the three outcome measures. All-girls students showed the highest gain in attitude compared to others with co-educational students showing the least. However, no significant effect of gender was found across all measures. It was therefore concluded among others that curriculum model and school type may be responsible for differences in science outcome previously attributed to gender.

INTRODUCTION:

The third world countries are more than ever before in need of purposefully trained scientists if they must compete favourably with other more advanced countries of the world in this twenty-first-century stage. The purposefully trained scientists must contribute to driving society to the effective functioning of industries, designing and constructing of roads, fabrication of equipment and tools, research in different sectors of economic life, and all aspects of nation-building. The inability to produce individuals well trained in doing these has been blamed for the continued underdevelopment of the third world nations. Efforts to stern the tide have resulted in a series of teaching experiments aimed at improving the quality of science learning among secondary school students. The efficacy of the learning cycle as a pedagogic tool for the improvement of students’ scientific reasoning skills and knowledge has been identified (Marek and Methven, 1991; Moemeke, 2007; Abraham, 1998). Efforts at gaining knowledge about its efficacy have uncovered two learning cycle curriculum models -the hypothetico-predictive learning cycle and the descriptive learning cycle among others have uncovered two learning cycle curriculum models-hypothetic-predictive learning cycle and the descriptive learning cycle among other (Lavoie 1999). The descriptive learning cycle is an epistemological framework found to help students improve their understanding of science concepts (Karplus and Their, 1967; Abraham, 1998; Karplus, 1977). The Hypothetico-predictive learning cycle on the other hand is a science pedagogical arrangement that incorporates two important process skills of science into a learning cycle framework and adds impetus for removing students' barriers to thinking and imagination (Lawson, 2000, Lavoie 1999).

The influence of gender on the Nigerian science classroom has been variously studied (Lee & Lockheed, 1990, Moemeke, 1999; Okwo, 1990; Omoifo, 1996,2004). It seems to be some disagreement about the effect of the students' sex on the ability to learn science and benefit from science curriculum models. While some studies reported gender differences some other studies showed no significant difference in attitude and achievement. However scientific reasoning skill acquisition, which is a major objective of science teaching in this millennium seems not to have been well studied especially within the gender. The forms of this study thereof focus is to investigate the effect of the learning cycle curriculum models on male and female students learning of science.

The present study adopted the Karplus 3-phase curriculum model. The idea is to determine if there is a disparity in male and female students' ability to learn science and to ascertain its efficacy in preparing young secondary school science students for future scientific endeavours.

This study, therefore, asks the question: to what extent do the learning cycle curriculum models affect gender science learning in Nigeria? Studies on the effects of the learning environment on students' performance in learning outcomes (Mallam,1993; Hopkin,2001) revealed significant differences in the achievement of single-sex and co-educational students. Young and Fraser (1994) also stated that most differences in learning attributed to gender were actually due to school type. It is not known if the same is the case in Nigeria. This study, therefore, asks thus: to what extent does school type (All-boys, All-girls, and Co-educational) affect students learning of science? Would method interact with school type to affect science learning? To enable this investigation, the following null hypotheses were tested.

1) There is no significant difference in science learning of students in the three treatment groups [Hypothetico-predictive learning cycle (HPLC), Descriptive learning cycle (DLC), and Traditional expository approach (TEA)]
2) There is no significant difference in science students' attainment of scientific reasoning skills, and achievement in science attitude towards science after treatment.
3) There is no difference in the attainment of students from all-boys, all-girls, and co-educational school types.
4) There is no significant effect of male and female students' attainment in science.
5) There is no significant interaction effect of curriculum models and school type on students' attainment in science learning.
6) There is no significant interaction effect of curriculum model and gender on students' science learning.

The result of this study will apart from determining the efficacy of the learning cycle curriculum models in science instruction, also determine if differences exist in the ability of males and females to acquire skills, attitudes, and knowledge for functional science thereafter.

METHODOLOGY

The study involved two hundred and seventy-three (273) senior secondary school Biology students from three secondary schools in Delta State, Nigeria. Nine intact classes (three from each school) were randomly assigned to treatment groups in this study. Thus, a quasi-experimental (non-equivalent group) in a 3x3 x 2 factorial design was adopted. The independent variables were curriculum model in three levels (HPLC, DLC, and TEA), School type in three levels (All-boys, all-girls, and co-educational,) and sex in two levels (male and female).

Table 1. Distribution of subjects by method by sex by School type

Method										
	DLC			**HPLC**			**TEA**			**TOTAL**
	Co – Ed	All Boys	All Girls	Co – Ed	All Boys	All Girls	Co – Ed	All Boys	All Girls	
M	18	32	--	24	39	--	14	32	--	159
F	16	--	21	10	--	10	42	--	15	114
	34	32	21	38	39	10	56	32	15	273
Total	87			83			103			273

The researcher designed three types of classroom procedures for the teaching of six selected topics in Biology. The topics are.

- Osmosis in living tissues
- Evidence of photosynthesis
- Regulation of internal environment (Homeostasis)
- Feeding relationship in an ecosystem
- Enzymes and
- Tropical rainforest

The classroom procedures for the HPLC group included a hypothetic-predicative worksheet designed to prompt students to make hypotheses and predict experiments in order to reveal alternative conceptions held by students on the topic at hand. The HPLC and DLC were similar in all respects except for the predictive stage in the HPLC which precedes the 3-phase learning cycle (exploration. term introduction and application). The TEA group received instruction on the same topics using the lecture method.

Treatment lasted for six weeks, prior to which one week was devoted to orientation and interactive sessions. The last week (8th) was used to collect Data for this study. This was achieved using three instruments

1) Test of science achievement (TSA), a 45-item instrument will reliability coefficient of 0.7.3 by KR- 21 formula.
2) Test of scientific reasoning skills (TSRS), A 10 – Item test of logical reasoning. The items were drawn from the contents of instruction but adapted after Lawson’s (1995) logic tasks as used by Norman (1997) in which each item bore a condition or factor that would produce an effect. The subjects were therefore to identify the condition which could cause an effect or an off-set. K – R 21 yielded a rehabilitee co-efficient of 0.40. The low-reliability co-efficient according to Pallant (2001) is common to short scales (items 10 and

below) since reliability co-efficient are sensitive to the number of items on the scale.

3) Test of attitude towards science (TATS), a 29-item Likert scale with 16 positively and 13 negatively worded items. The reliability coefficient was found to be 0.81 by Cronbach alpha.

RESULTS

Data generated were analyzed using 3 x 3 x 2 repeated measures analysis of variance (3–way ANOVA)

Table 2: Distribution of means of posttest science learning outcome method by school type by repeated measures

Method	School type		Learning outcome		
		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 3: ANOVA Summary for effects of treatment (curriculum model), school type, and repeated measures (science outcome) on science post-test learning outcome as repeated measures.

Source	**SS**	**df.**	**MS**	**F**	**P**
Method (Treatment)	25334.55	2	12667.28	77.35	0.00
Repeated Measures (Learning Outcome	161158.07	2	80579.04	492.05	0.00

School Type					
Method* Repeated Measures	10297.57	2	5148.78	31.44	0.00
Method* School Type	3480.60	4	870.15	5.31	0.00
Repeated Measure* School Type	3639.78	4	909.95	5.56	0.00
Method* Repeated Measures*	2462.28	4	615.57	3.76	0.01
School Type	3540.11	8	442.51	2.70	0.01
Error	129700.46	792	163.76		
Corrected Total	401812.81	818			

* P ≤ 0.05 is significant

Table 4: Post hoc analysis of the direction of significance using Sheffe test.

i Type of treatment	**j** Type of treatment	**Mean difference (i-j)**	**Standard Error**	**Sig**	**95% Confidence**	
					Lower bound	**Upper bound**
DLC	HPLC TEA	-10.40 4.21*	1,15 1.07	0.00 0.00	-13.22 1.59	-7.59 6.82
HPLC	DLC TEA	10.40* 14.61*	1.15 1.10	0.00 0.00	7.59 11.92	13.22 17.30
TEA	DLC HPLC	-4.21 -14.61	1.07 1.10	0.00 0.00	-6.82 -17.30	-1.59 -11.92

Table 5: Post hoc analysis of the direction of significance using Sheffe test

i Repeated Measures	**j** Repeated Measures	**Mean differen ce (i-j)**	**Standard Error**	**Sig**	**95% Confidence**	
					Lower bound	**Upper bound**
SRS	Ac. In Sci. Att. Towards sci	9.72* -29.13	1.10 1.10	0.00 0.00	7.03 -31.81	12.41 -26.44
Ach. In Sci..	SRS Att. Towards Sci.	-9.72 -38.85	1.10 1.10	0.00 0.00	-12.41 -41.53	-.7.03 -36.16
Att. Towards Sci..	SRSI Ach. in sci.	29.13* 38.83*	1.10 1.10	0.00 0.00	26.44 36.16	31.81 41.53

Based on observed means

- The mean difference is significant at the P ≤ 0.05.

Table 6: Post hoc analysis of the direction of significance based on school type using the Schaffer test

i School type (Ethos)	j School type (Ethos)	Mean difference (i-j)	Standard Error	Sig	95% Confidence	
					Lower bound	Upper bound
Co – Ed	All Boys All Girls	-9.21 -4.75	.98 1.28	0.00 0.00	-11.63 -7.88	-6.79 -1.62
All Boys	Co –Ed All Girls	9.21* 4.46*	.98 1.31	0.00 0.00	6.79 1.25	11.63 7.67
All Girls	Co – Ed All Boys	4.75* -4.46	1.28 1.31	0.00 0.00	1.62 -7.67	7.88 -1.25

Based on observed means *The mean difference is significant at the $P \leq 0.05$.

Table 7: Distribution of means of group by sex by repeated measure

		INITIAL ABILITY LEVELS			
		Low 0 – 12	Medium 13 – 15	High 16 – Above	Total
DLC	M F TOTAL	40.39(60) 39.48(36) 40.00(96)	46.04(61) 45.72(30) 45.93(81)	54.86(39) 45.12(45) 49.64(84)	46.08(150) 43.46(111) 54.53(261
HPLC	M F TOTAL	48.04(36) 68.30(3) 49.60(39)	48.74(42) 51.02(9) 49.14(51)	59.07(108) 59.01(42) 59.05(147)	54.53(42) 58.20(54) 55.36(237)
TEA	M F TOTAL	37.32(51) 38.46(120) 38.12(171)	43.77(39) 44.72(42) 44.26(81)	43.59(54) 41.66(15) 43.17(69)	41.42(144) 40.21(177) 40.75(321)
Total		41.20 (147) 39.25(159) 40.19 (306)	46.23(132) 45.06(81) 46.06(213)	54.02(196) 50.33(102) 52.77(300)	40.75(321) 44.11(342) 46.32(819)

Table 8: 3-way ANOVA summary of model by gender and ability.

Source	SS	df.	MS	F	P
Model Sex Initial ability Model *Sex Model* Initial ability Sex * Initial ability Model*Sex*Initial ability Error Corrected Total	10578.85 162.75 2233.44 1715.19 2431.71 1822.04 839.11 356619.90 401812.81	2 1 2 2 4 2 4 801 818	5189.43 162.75 1116.72 857.59 607.93 911.02 209.78 445.22	11.66 0.37 2.51 1.93 1.37 2.05 0.47	0.00 0.55 0.08 0.15 0.24 0.13 0.76

Table 3 showed that the F- value for model effect is 77.35 with df=(2, 792) significant at 0.00 level of significance ($p < 0.05$). Curriculum model produced a significant effect on students' science learning outcome. Null Hypothesis 1 was thus rejected (means =44.96,55.36 and 40. 75 for DLC, HPLC, and TEA respectively. Post hoc (table 4) revealed that the DLC was significantly different from TEA (mean difference=4.21), HPLC significantly different from DLC (means difference =10.40) and HPLC significantly different from TEA (means difference 14.61). The order of efficacy of the models as shown by the mean differences is thus represented thus: HPLC>DLC> TEA.

The F-value of science learning outcome in Table 3 is 492.05, significant at 0.00 and df = (2, 279). Null Hypothesis 2 was of no significant difference in science learning outcome and was thus rejected. Students differed in their attainment in scientific reasoning skills, science achievement, and attitude towards science across the treatment models (means 39.8.5, 30.13, 68.98) respectively. Sheffe multiple comparisons revealed (Table 5) that the difference between reasoning skill and science achievement was 9.72, between attitude towards science and scientific reasoning skill 29.13, and between attitude towards science and achievement in science was 38.85. The order of attainment in science learning outcome is attitude towards science followed by scientific reasoning skills and finally achievement in science concepts.

In testing null hypothesis 3 which states a no significant effect of school type. Table 3 showed the F-value of 31.44 with df= (2,792) significant at 0.00 level of significance. The null hypothesis was thus rejected. Sheffe (table 6) showed the mean difference of All boys and Co-ed to be 9.21, All boys and All -girls to be 4.46, and All-girls and Co-ed students to be 4.75. The variation is widest between All-boys and All-girls followed by All girls and co-ed and finally All boys and Co-ed students.

Table 3 also showed the F- value of model by school type interaction to be 5.56, df=(4,792), significant at 0.00 level. Thus, null hypothesis 4 in this study is rejected. Graphical representation of the cell means showed that the interaction is disordinal. The difference in the science learning outcome was in favour of All-boys students within the DLC group. In the HPLC group, the difference is in favour of All-girls students followed by All-boys students. In all groups, students were more responsive to the HPLC model followed by the DLC and TEA.

On the effect of sex or science students learning of science, table 8 showed an F-value of 0.37 with df = (1, 201), significant at 0.44 (which is higher than the 0.05 level set of this study). The null hypothesis 5 which stated that there is no effect of student's sex on attainment in science learning outcome was retained. Sex (F-value 1.93, df=2,801) therefore does not affect attainment in all treatment groups. Students' sex was also found not to significantly interact (hypothesis 6) with treatment model in determining their attainment in science learning outcomes. The differences in mean noticed were only apparent and may be due to sampling fluctuation.

DISCUSSION

The high efficacy of the HPLC curriculum model over the DI.C and TEA was established by this study (55.36 > 744.96 > 40.75 for HPLC, DLC, and TEA respectively) corroborates the results reported by Douglass and Kahle(1977), Hurst and Mlilkent (1996). Lavoie (1999) and Lawson et al (2000). Several reasons were advanced to support this finding, some of which include the opportunity to help learners test knowledge claims, removing dissonance, fostering Collaboration while doing science as well as the development of knowledge patterns and exposing learners' alternative conceptions. These according to Okebukola (1997) impede science learning. Using the model limited their influences and provided the impetus for effective science learning. The DLC model also produced better outcome compared to the TEA as previously reported in the literature. The report however is at variance with Marek and Westbrook (1990) which reported poor process skill acquisition by students taught with the DLC model. It is possible that the descriptive nature of the script which ordinarily should encourage conceptual invention impeded student understanding of the instruction. Strengthening it with other science teaching strategies may further enhance its utility in the achievement of some important science education objectives.

The two learning cycle models in this study enhanced students' attitude to science and scientific reasoning skills more than they did to achievement in science. This is the trend in Gang (1995) and Lawson (1995). The importance of this result can be appreciated if we consider the fact that several factors such as motivation, teachers' instructional practices, interest in and opportunity to interact with the environment influence attitude towards science. Simpson and Oliver (1990) and Hegarty-Hazel (1990) have reported that attitude towards science is influenced by nature of science instruction which in turn affects achievement but not vice Vasa. The effect of the learning cycle models in enhancing scientific reasoning skills is instructive since scientific reasoning skill is an important objective of science teaching rarely achieved by most science instructional procedures. In this study, though gen students' sex was found not to be significant, school type showed significant effect on science learning. The better attainment of single-sex students over co-educational arrangements may be accounted for by.

1) Removing distractions due to opposite sex
2) Increased commitment to school work in single-sex schools

3) Removing sex stereotyping that breed inferiority and inhibition in co-educational schools and encouraging self-esteem and high personality concept in single-sex schools.

It is instructive to note that single-sex schools may provide the usual psychological and social environment found among peers of the same gender. Issues of inequality in attention and bias during teaching and communication in the classroom may impede communicative discourse which is an important aspect of science learning.

CONCLUSION:

Based on the results of this study, the following conclusions were made

- Instructional model (curriculum) model used for science instruction affects the extent of, and type of science learning in the classroom.
- The learning cycle models enhanced students' attainment in all outcome measures studied.
- HPLC showed high potential for promoting science learning objectives.
- All sexes benefit from the learning cycle models (HPLC being the most efficacious).
- Learning cycle models enhanced the acquisition of important science learning outcomes such as scientific reasoning skills which mere exposition cannot achieve.
- Student gender did not determine attainment in science learning.
- Single-sex schools produced better attainment in all groups than co-educational students.

Implications for the training of prospective young scientists

These findings have serious implications for the production of future young scientists for the much-needed scientific and technological upliftment of Nigeria as a developing nation.

Teaching science with expository methods endangers the achievement of important science learning outcomes one of which is the development of thinking skills. The inability of the expository group to attain maximally is unconnected with its tendency to encourage rote memorization and ignore the acquisition of intellectual and process skills of science. These skills are basic necessities for functional science. The learning cycle models encourage and utilize participatory science activities which draw the young learners of science not only close to science but to doing science the way scientists do. Science is both a process and a product. The process is not only procedural but communicative. Today's young people are full of questions and doubts, which if not cleared, produce cognitive conflicts which are barriers to science. The hypothetico- predictive phase of the learning cycle provides the normal but informal atmosphere for young people to interact and overcome the presumed fear and barriers associated with traditional didactic science classrooms. The implication is that young learners are left in control of their consciousness thus demystifying science. This makes sciencing a pleasant experience for young people.

Connected to the above is the fact that literature is apt about the effect of intrinsic motivation on attitude, attainment, and productivity. The attitude-boosting effect of the learning cycle models provides a possible impetus for future achievement. Related to this is the nature of the African child and the traditional scientific methodology which is practical, participatory, and apprenticeship in approach. The didactic science classroom reminiscent of western verbal exposition may have some roles to play in science underachievement and poor enthusiasm to do science. The learning cycle model parades the ideal which combines the apprenticeship relationship and the investigative communicative discourse usual in western science. Effective preparation of future scientists must begin with well-laid foundation of the nature of science. Hypothesizing, predicting, and reasoning around problem situations are process skills of science that are tightly fitted to the nature of scientific thought that the models emphasized. Any instructional model that deliberately targets the acquisition of these skills has the potential for developing young school leavers capable of inventive science careers.

Not to be underestimated is the influence of the sequence of phases in the learning cycle models. Each of those phases enables the development of patterns that draw a link between science classroom concepts and those in other fields as well as life activities in the environment thus enhancing lifelong and holistic science learning.

All sexes are capable of learning and doing science if provided with appropriate pedagogical arrangements has innumerable implications for the production of future scientists in Nigeria. The teaming populations of females who are discouraged from active science by some classroom procedures that engender gender inequity have shown equitable responsiveness to the learning cycle model.

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