The Effect of Constructivist ICT-Mediated Instruction and Programmed Instruction on Children's Learning Outcomes in Science

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Abstract
This paper studied the effect of constructivist ICT-mediated instruction and programmed instruction on the learning outcomes of children in science. The research employed a quazi-experimental design using a 3x2x2 factorial matrix. The design involved three groups; pretest, posttest and control group. Forty (40) pupils from both MOCPED International Nursery and Primary school and SPEB Demonstration Primary School, at Epe Local Government Area of Lagos State were purposively sampled. The instrument used were a researcher designed Programmed Instructional Package (PIP,) Science Achievement Test (SAT); and Science Attitude Questionnaire (SAQ). The experimental groups were instructed using the PIP and a constructivist ICT-mediated instruction while the control group was not introduced to any treatment. The pretest and post-test scores of the groups were analyzed using the Analysis of Variance (ANOVA) and T-test statistics at 0.05 level of significance. Interaction effect was controlled using the Analysis of Covariance (ANCOVA). The result shows that children taught using the Programmed instruction performed better than both students in the constructivist ICT-mediated instruction and the traditional group. There was no significant effect of the treatment on the gender of the pupils. Also, the attitude of the children to learning science in the three groups was statistically different. It is recommended that PIP and constructivist ICT- mediated instructions be introduced into the science curriculum as media of instruction among other things.

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Introduction

The pace of change brought about by new technologies has had significant effects on the way people live, work and play. As technologies changes everyday, its use in every aspect of the society cannot be overemphasized. Worldwide acceptance of its integration into the teaching and learning process has therefore posed an urgent demand on learners to develop higher order thinking. In order for students to meet up with this demand, there is need to learn at the primary school level, science, which is an indispensable part of the curriculum. Science education has come a long way towards improving information systems worldwide, and the drive so far has been towards educating people to be scientifically and technologically conscious and literate. The primary school which is the preparatory stage for the learning of science in our children is the stage to inculcate science skills in order to be useful within the society. Since today's education is no longer adequate preparation for tomorrows computerized society, the teaching of science which forms the basic scientific and technological growth of any nation requires a high quality teaching force to be able to cope with the dynamics of the changing world.

Researchers (Seweje & Jegede, 2005; Ogundola, 2010) were of the opinion that several instructional strategies that have been employed by teachers for the teaching of science and mathematics over the years are teacher-centered which do not cater for individual differences in the learner. They stressed further that students are taught the same thing at the same rate without taking into consideration student's assimilation rates, thereby unable to identify weak students in the class. Also Odubunmi, (1996) and Murphy (2003) among others opined that student performance is low and the problem of declining interest in science is now an international issue. This was corroborated by Ogunleye (1999), that adduced reasons such as explosion of primary schools, teachers low knowledge about the goals of science teaching, lack of basic process skills of science that is necessary for imparting the knowledge, language of instruction, inadequate and shortage of primary science instructional materials as well as overloaded curriculum content and methods as impediment to the understanding of science by students.

However, it is hoped that with the integration of necessary ICT tools in primary science, pupils interest, curiosity and understanding of science will be heightened. Currently, the primary use of computers in education has been to deliver programmed instruction including drill and practice programs, computer based tutorial and more recently intelligent tutoring systems. These computer softwares are used in schools to teach students like what the teachers normally do. The prominent form of programmed instruction is the drill and practice programs especially in the areas of mathematics. He said further that drills are based on behaviorist beliefs about reinforcement of stimulus response association. Unfortunately the behaviourist principles underlying drill and practice are unable to develop the complex thinking skills required for meaningful learning to take place in science. Although drill and practice applications train learners, to perform the lower level sub-skills automatically but do not facilitate the transfer of those skills necessary for solving real and meaningful problems in science. With constructivism, learners are engaged in knowledge construction. They come to classroom with their unique backgrounds, experience, and conceptual understanding, learning styles and personal circumstances. Teachers now become learning facilitators rather than reservoirs of knowledge. That

was why Piaget (1972) opined that psychology of learning has shifted from behaviorism to cognitivism. It is believed that activities such as enquiry, investigation, problem solving, inferences, predicting when carried out collaboratively and accompanied by effective teacher dialogue can bring about understanding of scientific concepts. Murphy (2003) in support of the above assertion said if such type of activities is promoted by a constructivist approach to science teaching as opposed to behaviourist programmed instruction will be most beneficial in bringing out good learning outcomes in our children. The researchers are therefore interested in studying the effect of constructivist ICT-mediated instruction and programmed instruction on children's learning outcome in science.

Literature Review

Science is simply the dynamic study of nature and is in itself social and culture related, hence the environment is extremely significant when considering various aspects of science. Globally, science education programmes have afforded tremendous opportunities to young scientists in training in terms of acquisition of skills for solving, in particular, environmental problems. As stated by Akpan (1996) secondary school science curriculum is designed towards making everybody to become a specialist in the science professions later in life, but at the end of the day, many people are increasingly being alienated from science. The number of science and engineering graduates is falling, just as demand for scientific advances and technological innovation is increasing (OECD 2006), and many students tend to switch to other subjects that are more interesting and less demanding because a white coated, hardworking and poorly paid scientist in a laboratory is not a role model for many of today's young people. The reason for this is not farfetched, the objective of science education is the development of science process skills among school age children but in Nigeria, science teaching at the various levels retains the old conservative approach with the teacher, in most cases acting as the repertoire of knowledge and the student the dominant recipient. There is an over reliance on textbooks, shortage of scientific equipment, cognitive functioning of students, school conditions, teachers methodology, overloaded science content among others.

Moreover, current science curricular reform efforts throughout the world have re-focused on the necessity of teaching students to make informed and balanced decisions about how science impacts their lives and to use scientific knowledge to solve problems (Council of Ministry of Education, 1997). It is on that note that the researcher tends to study how both programmed instruction and constructivism affects learning outcomes in science.

The programmed and Constructivist-based learning environment

Programmed instruction and constructivism are both theories of learning. Programmed instruction is based on operant conditioning, it is a reductionist and focuses on external control and reinforcement. Skinner in Karen (1995) described programmed instruction as having a clearly defined context which is presented in small increments. As small units of the contest are presented, a learner is presented with a question that must be answered (stimulus). The student answers (response) and is told whether the answer is correct (consequence). On the other hand, constructivism

approaches view learning as a process in which individual students construct or build their own internal interpretations of external events.

Constructivism has its root in psychology, philosophy, sociology, and education. Constructivist teaching approach is based on the work of Rousseau, Dewey, Piaget, Bruner and Vygotsky and they all believed that human learning is constructed and active rather than a passive process. It has major implications for science teaching and it calls into question the traditional practices and places the child at the centre of the learning process. While Piaget and Bruner's work contributed towards cognitive constructivism, Vygotsky's work contributed towards social constructivism. In a constructivist learning environment, learners may work together and support each other as they use a variety of tools and information resources in their pursuit of learning goals and problem solving activities (Wilson, 1995), and learning is a personal interpretation of the world, where learners create interpretations of the world based on their past experience and interpretations (Jonassen, 1994; Jonassen and Henning, 1999). Their learning depends not only on the learning environment as set up by society, school and teacher but also on their prior knowledge, attitudes and aspirations. In constructivism the teacher is no longer perceived as the sole authority of the knowledge, but rather as the facilitator of learning, guiding and supporting learners in the process of constructing knowledge (Berg, 1999) and providing students with experiences that allow them to develop problem-solving, critical thinking and creative skills, and apply them in a meaningful manner.

Murphy (2003) states that computer tools are one of the easiest means of incorporating constructivist theory into education use. Learners are then working in authentic situations which should increase their comprehension of how to use ideas and information (Duffy and Jonassen, 1991). They also suggest that such things as hypertext, databases, and expert systems can be used as mindtools by individuals. Nevertheless, criticisms have been leveled against the constructivist approach to science teaching in the primary school. The most frequently quoted is while research advices that teachers identify children's alternative frameworks, there is little advice for teacher regarding specific strategies to develop these ideas so that they become more scientific particularly in class in which there might be up to 30 alternative frameworks for each concept.

Hypotheses

The study will make an attempt to answer the following questions.

1. There will be no significant difference in the performance of those pupils exposed to constructivist ICT-mediated instruction and programmed instruction in science teaching?
2. There will be no significant difference in the performance of those pupils exposed to constructivist ICT-mediated instruction and programmed instruction and conventional instruction in science teaching?
3. There is no significant effect of the treatments on gender of the students?
4. There will be no significant difference in pupil's attitude towards science when exposed to constructivist ICT-mediated instruction and programmed instruction?

Proposed Methodology

Research Design
The research adopted a quazi-experimental design using a 3x2x2 factorial matrix. The design involved randomized three groups; pretest, posttest and control group.

Population
The target population for this study was primary six pupils in public and private schools, Epe Local Government of Lagos State, Nigeria. Primary school pupils (Primary six) offering science at Michael Otedola College of Primary Education, {MOCPED} International Primary School, and Demonstration School, MOCPED, both at Epe Local Government Area of Lagos State. The choice of primary six pupils for the study is that they will soon transit to secondary school, and having the knowledge of science they can easily construct their own meaning.

Sample and Sampling procedure
The nature of this study required a purposive selection of the research sample, since this study requires such schools where computers, CD-ROMs, word processors, projectors, etc are used in science teaching. A total of Forty (40) pupils from the two schools were sampled out of the population.

Research Instrument
The instruments used were a researcher designed Programmed Instructional Package (PIP,) Science Achievement Test (SAT); and Science Attitude Questionnaire (SAQ). The PIP which is a multimedia program covers topics from Basic Science and Technology curriculum. The pupils were taught simple machines, with the subtopic: {Meaning and types of simple machines, types of lever, Pulleys and Inclined planes}. The PIP was designed using PowerPoint and in such a way that the pupils can refer back to the previous section in case they don't understand the previous section. Constructivist ICT-mediated instruction, the pupils worked in small groups of 4,4, 3 and 3. The lesson was carried out under the five steps to a constructivist teaching viz-a-viz: situation, grouping, bridge, questions, exhibit and reflections. Each group was given a chart which comprises the simple machines coupled with some real objects. They pupils were given a sheet of paper that provides series of questions on the name and the use of the machines given. The information gathered was then recorded on the computer data processor {MicrosoftWord 2007}. The control group on the other hand was taught using the traditional method. The lessons were taught for a period of two weeks after the pretest was conducted. The three groups were given the test items of the pretest and post test differently in their schools. On completion of the test, the scripts were collected, collated, mixed together and marked.

The Science Attitude Questionnaire (SAQ) was a 20-item structured questionnaire which was rated using the four point likert scale {strongly agree, agree, disagree and strongly disagree} in the form 4, 3, 2, and 1.

Validity of the Instrument
The face and content validity of the instruments were established by giving them to colleagues who are vast in the field and test and measurement professionals in the school of Education, MOCPED. Also, the PIP was made to pass through educational software developers in the department of Computer science, MOCPED.

Reliability of the Instrument
A pilot study was conducted on the pupils using the test-retest method. The established reliability coefficient for the instrument was 0.74 and 0.78 respectively and they were suitable for the study.

Administration of the instrument
Pre-treatment Phase
The three groups (constructivist ICT-mediated instruction, programmed instruction and the control group) were given the test without teaching them. The test was marked and recorded. The posttest was conducted after the treatments were applied on them. The scores were marked, collated and recorded.

Method of Data Analysis
Data analysis will be carried out using Analysis of Covariance to test the significance difference at 0.05 level of significance using Statistical Package for Social Scientists (SPSS) 20 as the statistical tool.

Table 1: Gender of Respondents

GENDER

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	MALE	18	45.0	45.0	45.0
	FEMALE	22	55.0	55.0	100.0
	Total	40	100.0	100.0	

The table above shows that 18{45%} are male while 22{55.0} are female.

Hypothesis One: There is no significant difference in the performance of those pupils exposed to constructivist ICT-mediated instruction and programmed instruction in science teaching?

Table 2: Mean table of Pretest and Posttest achievement of science of pupils in constructivist ICT-mediated, programmed and conventional instruction

	Teaching Methods	N	Mean	Std. Deviation	Std. Error Mean
Pretest Achievement	CONSTRUCTIVIST ICT MEDIATED INSTRUCTION	14	4.714	3.7505	1.0024
	PROGRAMMED INSTRUCTION	9	5.556	4.6128	1.5376
	CONVENTIONAL INSTRUCTION	17	7.235	3.2506	.7884
Post Test	CONSTRUCTIVIST	14	10.214	5.5077	1.4720

Achievement	ICT MEDIATED INSTRUCTION				
	PROGRAMMED INSTRUCTION	9	14.778	4.1164	1.3721
	CONVENTIONAL INSTRUCTION	17	9.412	2.9960	.7266

The table above shows the mean performance of pupil's in the pretests. The result reveals that the conventional group {7.235} performed better than the constructivist ICT-mediated instruction {4.714} and programmed instruction {5.556}. Constructivist ICT-mediated instruction has the lowest mean score. Pupils in the conventional group had a high score because they have been taught the first part of the lesson before the researcher got to the school. So, they had a brief knowledge of the topic which other groups did not have.

In the post test achievement however, the programmed instruction group {14.778} performed better than the Constructivist ICT-mediated instruction group {10.214} and the conventional group {9.412}.

Table 3: T-test table of pupils achievement in constructivist Science ICT-mediated and programmed instruction

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Post Test Achievement	Equal variances assumed	3.212	.088	-2.126	21	.046	-4.5635	2.1462	-9.0268	-.1002
	Equal variances not assumed			-2.268	20.390	.034	-4.5635	2.0123	-8.7560	-.3710

The analysis of table 4 above shows the test analysis of pupils exposed to constructivist ICT-mediated programmed and conventional instruction. The result shows that there is a significant difference in the performance of pupils with the mean score {10.214 {t= -2.126; p <.05} and {14.778{t= -2.268; p <.05} when exposed to constructivist ICT-mediated and programmed instruction. The null hypothesis of no significance difference was therefore rejected.

Hypothesis Two: There will be no significant difference in the performance pupils exposed to constructivist ICT-mediated instruction, programmed instruction and conventional instruction in science teaching?

Table 4: Analysis of Covariance {ANCOVA} table of pupils achievement in science in constructivist ICT-mediated, programmed and conventional instruction

Tests of Between-Subjects Effects

Dependent Variable: Teaching Methods

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	143.041[a]	1	143.041	93.040	.000
VAR0002	143.041	1	143.041	93.040	.000
Error	59.959	39	1.537		
Total	203.000	40			

a. R Squared = .705 (Adjusted R Squared = .697)

An examination of the results in table shows than an F {1, 39} = 93.040α = .000 for the treatment was significant at 0.05 level of significance. The result shows that the means scores of pupils in the three groups {constructivist ICT mediated instruction, programmed instruction and conventional instruction} produced a significant difference on the post test performance of students when the covariate effect {pre-test} was statistically controlled.

Hypothesis Three: There is no significant effect of the treatments on gender of the students?

Table 5: Analysis of variance {ANOVA} on the effect of treatments on the gender of the pupils

ANOVA

GENDER

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.200	14	.371	1.976	.067
Within Groups	4.700	25	.188		
Total	9.900	39			

From the analysis of the ANOVA on the effect of treatments on the gender of the pupils, it shows that {F = 1.976 = 0.67; p > 0.05}. This shows that F is not significant.

Hence we accept the null hypothesis and agree that there is no significance effect of the treatment on the gender of the pupils in science teaching.

Table 6 : Chi-square analysis on the effect of treatments on the attitude of pupils

Statements	Chi-square	df	Asymp. Sig.
I enjoy being taught science	12.600	3	.006
Science is not too abstract	8.400	3	.038
I do not like performing experiment on science	6.600	1	.086
Solving problems in science has widen my horizon	19.800	3	.000
I like reading about science	6.400	3	.011
Some science concepts are not too difficult, confusing and misleading	23.400	3	.000
Learning science has made me to know more about the world around me	17.150	3	.000
Learning science is not a worthwhile exercise	6.200	3	.102
Working problems in science is like a magic	1.800	3	.615
Science is not too technical for my liking	1.000	3	.801
The learning of science is fascinating and interesting	19.400	3	.000
I do not like to learn science subject	20.600	3	.000
I like the different courses one can study as a result of learning science	27.000	3	.000
The knowledge of science helps to develop good reasoning ability	3.400	3	.334
The knowledge of science is not relevant to my daily leaving	2.600	3	.457
Science has many technical terms which are difficult to understand	11.800	3	.008
I do not like watching documentaries on science	4.200	3	.241
Only very brilliant students can understand science	7.800	3	.050
Experiments in science are not interesting	30.000	3	.000

The table above shows the chi-square analysis on the effect of the treatments on the attitude of the pupils. It reveals that majority of the attitude questions are significant. Hence we reject the null hypothesis and agree that there is a significant effect of the treatment on the attitude of students after the post test was conducted.

Conclusion and Recommendation

The paper investigated the effect of constructivist ICT-mediated instruction and programmed instruction on children's learning outcomes in science. Four hypotheses were tested at 0.05 level of significance. Based on the findings of the researchers, it was concluded that

1. There is a significant difference in the performance of pupils exposed to constructivist ICT-mediated, programmed and conventional instruction.
2. That mean scores of pupils in the three groups {constructivist ICT mediated instruction, programmed instruction and conventional instruction} produced a significant difference on the post test performance of students when the covariate effect {pre-test} was statistically controlled.
3. There is no significant there is no significance effect of the treatments on the gender of the pupils in science teaching.
4. There is a significant effect of the treatment on the attitude of students after the post test was conducted.

Therefore it is recommended that:

1. Programmed instruction and constructivist ICT-mediated instruction should be introduced into the teaching of science curriculum as a media of instruction.
2. The government should train teachers both {pre-service and in-service} on the use of constructivist based learning and programmed instruction.
3. Curriculum planners should include the development of course content using ICT tools in the pre-teacher training curriculum.
4. Teachers should also be encouraged and motivated to search for new knowledge that will aid the teaching learning process.
5. Government should provide funds to schools because good teaching learning process with the aid of ICT cannot be achieved without enough fund.

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