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COMPARISON OF LEARNING CYCLE AND TRADITIONAL TEACHING APPROACHES ON STUDENTS' UNDERSTANDING OF SELECTED CONCEPTS IN ELECTRICITY

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ABSTRACT

Concept development has been the subject of ongoing debate among educators, academics and policy makers over the years. There have been many studies that sought to investigate the effectiveness of teaching methods in helping students develop and understand concepts in different subjects. The purpose of this study was to compare the learning cycle approach which is based on the constructivist theory to the traditional approach on senior secondary school students' understanding of selected concepts in direct current electricity. Two intact science classes from two of the six senior secondary schools offering General Science in the New Juaben Municipality were randomly sampled using the computer generated random numbers to participate in the study. In all 101 students participated in the study. The experimental group consisted of 59 students and the control group had 42 students. The main instrument used for data collection was Current Electricity Concept Achievement Test (CECAT) which comprised of 30 multiple choice items. The t-test for independent and dependent samples and linear regression were used to analyze data. The results of the study showed that the experimental group which was instructed using the learning cycle approach performed better on the posttest compared to the control group who were instructed using the traditional approach. The results also revealed that the learning cycle approach was more effective for teaching most of the interrelated concepts and a number of different aspects of the selected concepts in direct current electricity than the traditional approach.

Key words: *Conceptual change; Constructivist theory; Learning cycle; Preconceptions; Traditional approach.*

INTRODUCTION

Many researchers in science education, addressing effective concept development, base their studies on the constructivist perspective of learning. Constructivists view the learner as an active participant in the learning process who come to the science class already holding ideas about natural phenomena, which is used to make sense of everyday experiences and new situations (Wheatley, 1991). In this view, the most important ingredient or factor in the process of learning is the interaction between the new knowledge constructed and the existing knowledge. Students' preconceptions in science, while they interact with their physical and social environment, often conflict with the concepts as intended by scientists and this affect learning (Küçüközer & Kocakülah, 2007). Many such research findings support strongly the assertion that learners of all ages hold their own views about a wide range of physical phenomena prior to their formal learning of science in schools (Gunstone, 1991). Previous research has also shown that it is difficult for students to change their initial ideas in physics because their own beliefs are grounded in long personal experiences (McDermott, 1991; Wandersee, Mintzes, & Novak, 1994).

Direct current electricity is one of the major topics in physics studied and taught in pre-tertiary schools and tertiary institutions. However, several studies have indicated that many students in science classes have difficulties in understanding and learning these concepts. For instance, Engelhardt and Beichner (2004) found that both high school and university students' reasoning patterns regarding direct current resistive electric circuits often differ from the currently accepted explanations. Pfister (2004) and Carlton (1999) reported that many beginning physics students have harder times understanding basic concepts of electric circuits which arise due to the fact that students cannot see electric charge carriers (electrons) move through electric wires. Even university students who undertake advanced physics courses whilst in high schools have difficulties understanding basic concepts on topics related to electricity, as do middle-school students (Choi & Chang, 2004). The Chief Examiner's reports on the Senior Secondary School Certificate Examination (SSSCE) held in the years 2000, 2001, 2002, 2003 and 2006, also indicate that students have difficulties in understanding concepts in direct current electricity.

Few of the weaknesses identified are: most candidates were not able to draw electric circuits and interpret them (WAEC, 2002); the experiment on the determination of the resistivity of a wire was poorly done (WAEC, 2001 & 2002); majority of the candidates were not able to apply Kirchhoff's laws to the separate branches of the electrical network (WAEC, 2000); majority of the candidates failed to recognize the relationship between resistance and the balance lengths on the meter bridge wire (WAEC, 2003) and candidates wrongly stated the definition of certain concepts: an example is the definition of a junction as a point where two or more current meet instead of a junction is a point where three or more wires meet (WAEC, 2006). These weaknesses are evidence that students have difficulties in understanding concepts in direct current electricity.

While researchers have identified some learning difficulties of students resulting from their preconceptions and misunderstanding of concepts in science, consensus has not been reached on appropriate pedagogical strategies to address adequately these difficulties (Ates, 2005). Several research-based pathways have emerged following the constructivist perspective on teaching and learning of concepts in electricity. Some studies suggest analogies and analogical reasoning as a vehicle for inducing conceptual change (Psillos, 1998; Scott, Asoko & Driver, 1991) while others suggest the use of cognitive conflict and the solution of the conflict to foster conceptual change (Posner, Strike, Hewson, & Gertzog, 1982; Marek, Laubach & Pedersen, 2003).

The learning cycle is an approach of teaching and learning which increases the likelihood that students are engaged in the type of thinking that constructivists argue is necessary for productive thinking. It is a three-phase teaching approach ('exploration', 'term introduction' and 'concept application') which is developed based on Piaget's developmental theory (Lawson, 2001). This approach has proven effective at helping students to construct concepts and conceptual systems as well as develop more effective reasoning skills because it starts with students' viewpoint rather than the teacher's or scientist's (Liew & Treagust, 1998; Yilmaz & Cavas, 2006). However, the traditional teaching method where teachers transmit most of the knowledge to students with heavy emphasis on formulas and solving of quantitative problems still dominates most science instructions (Yanfeng, 2004).

The effectiveness of a method on students understanding of concepts can be determined only by comparing it to another method. This study was therefore conducted to compare the learning cycle approach and the traditional approach on senior secondary school form three (3) science students' understanding of selected concepts in direct current electricity. The study sought answers to the following questions:

1. What are the differences in achievement between students instructed on selected concepts in direct current electricity using the learning cycle approach and those instructed using the traditional teaching approach?
2. How effective is the learning cycle approach in teaching the interrelated concepts and a number of different concepts involved in direct current electricity?

METHODOLOGY

A pretest-posttest two group nonequivalent quasi-experimental design was used in the study. Two intact form three (3) science classes from two of the six senior secondary schools offering the General Science programme in the New Juaben Municipality were randomly sampled using the computer generated random numbers to participate in the study. In all 101 students participated in the study. One of the classes (n = 59) was randomly assigned as the experimental group and the other class (n = 42) as the control group. In the control group, the traditional teaching approach was applied;

whereas in the experimental group, the learning cycle approach was applied. In both groups, the lessons were taught by the researcher. Both groups however, covered the same content of the selected concepts in direct current electricity. Students in both groups took a pretest to measure their prior knowledge of the selected concepts before instruction and a posttest after instruction respectively to determine students' academic achievements regarding the strategies used. The study, including testing lasted for about three weeks.

INSTRUMENTATION

Data was gathered using a concept understanding test called Current Electricity Concept Achievement Test (CECAT) for both pretest and posttest. CECAT was developed by the researcher and consisted of thirty (30) multiple choice test items. In developing CECAT, a set of instructional objectives were constructed after consulting the senior secondary school syllabus and textbooks for information on the subtopics treated under direct current electricity. The instructional objectives (IOs) are shown in Table 1. The reliability of CECAT was calculated using KR-20 and was found 0.76. The validity of the test was checked by two experienced physics teachers and two physics lecturers in the Department of Science and Mathematics Education. The discrimination and difficulty indices of the test were also determined and found to be adequate.

Table 1: Instructional Objectives for Current Electricity Concepts Achievement Test (CECAT) and Question Numbers

Instructional Objectives	Question Numbers
Physical aspects of electric circuits	
1. Identify and explain a short circuit (i.e. more current flows through the path of lesser resistance).	13, 24
2. Explain the functional two-endedness of circuit elements (i.e. circuit elements have two possible points with which to make a connection).	18
3. Identify a complete circuit and acknowledge the necessity of a complete circuit for charges to flow in a steady state.	28
4. Apply the concept of resistance to a variety of circuits.	5, 9, 10
5. Interpret diagrams for a variety of circuits including series, parallel and combination of the two.	6,17, 19
6. Apply the conceptual understanding that the battery is a source of electrical energy.	7
Current	
7. Apply the conservation of current to a variety of circuits.	3, 12
8. Explain the microscopic aspects of charge flow in a circuit.	1, 2, 22, 30
Potential difference	
9. Apply the knowledge that the amount of current is influenced by the potential difference maintained by the battery and resistance in a circuit.	4, 8, 11
10. Apply the concept of potential difference to a variety of circuits including the knowledge that total potential difference in a series circuit is the sum of all the individual potential difference whiles in a parallel circuit the total potential difference is equal everywhere in the circuit.	13, 14, 15 20, 21, 23, 25
Current and Voltage	
11. Combine the concepts of current and potential difference to a variety of circuits.	26, 27, 29

TREATMENTS

The Learning Cycle Teaching Approach

This approach is a student-centered teaching procedure and offers another way of teaching science concepts in which students learn from their experiences, rather than through other learning methods which rely solely on textbooks for classroom learning. The learning cycle teaching approach used went through three essential phases as follows:

1. Exploration: This phase typically consists of hands-on activities or field experience in which students gather and record data from their observations and measurements. The purpose of this phase is that students are encouraged to learn through their own experience. Students were informed about an experiment or demonstration which will be performed. Students were put into groups to perform activities. During each practical activity lesson, a set of materials were given to students to perform the experiment. Every student was given an activity sheet containing instructions to be followed. On this sheet, spaces were provided for students to write their predictions before performing a specific task, then make observation and draw conclusions after each activity. When their predictions and observations are inconsistent with each other, the students' explanations are explored. This helped students to reconcile their prior ideas with their current observations.
2. Term introduction: The Researcher toke an active role in leading the students to develop the concept. Students used their experience from exploration phase to develop an understanding of the science concept and explain the science concept with guidance from the teacher.
3. Concept application: Students were given the opportunity to directly apply the concept learned during the term introduction phase. Exercises and assignments were given to students to do.

This approach was used to teach all the selected concepts in direct current electricity to students in the experimental group.

The Traditional Teaching Approach

It involves the teaching of topics in a regular physics course where teaching-learning activities are teacher centered. The Researcher prepared his notes and did most of the talking during the teaching process. He presented the scientifically correct concepts to students, then asked students to do laboratory activities to confirm the concepts and then gave exercises related to the concepts learnt. The Researcher answered students' questions and occasionally asked students some questions. After marking students' assignments or class exercise, he distributed the marked scripts to students to effect the necessary corrections. Students were put into groups during practical sections but individual students developed their experimental reports where necessary. Students were encouraged to discuss among themselves when performing the activities. The above approach was used to teach all the selected concepts in direct current electricity to students in the control group.

RESULTS AND ANALYSIS

The two groups' scores from the pretest were compared using the t-test for independent samples. As shown in Table 2, there was no statistically significant difference between the mean scores of students in the experimental and control groups with respect to CECAT before instruction ($t(99) = 0.035$, $p = 0.972$). The results indicate that on the average, students in both groups had similar preconception of the selected concepts in direct current electricity and they had started the treatments with nearly the same level of learning.

Table 2: Results of Independent Samples t-test for Pretest Scores of Experimental and Control Groups

Variable	Groups	N	Mean	SD	t	df	p
Pretest	Experimental	59	10.54	2.575	0.035	99	0.972*
	Control	42	10.52	2.616			

*Not significant, since $p > 0.05$

Since there were no significant differences between the experimental and control groups' mean scores in terms of pretest, the pretest and posttest scores of each group were compared using the t-test for dependent samples. As shown in Table 3 there is a statistically significant difference between the two groups' pretest and posttest scores. The experimental group's mean score from posttest (M = 21.14, SD = 2.240) was significantly higher than the mean score from the pretest (M = 10.54, SD = 2.575, t (59) = -21.177, p = 0.001).

This means both the traditional and the learning cycle approaches had a significant effect on students' understanding of the selected concepts in direct current electricity.

Table 3: Results of Dependent Samples t-test for the Pretest and Posttest Scores of Experimental and Control Groups

Groups	Tests	N	Mean	SD	t	df	p
Experimental	Pretest	59	10.54	2.575	-21.177	58	0.001*
	Posttest	59	21.14	2.240			
Control	Pretest	42	10.52	2.616	-8.918	41	0.001*
	Posttest	42	16.07	2.722			

*Significant, since $p < 0.05$

To investigate possible significant difference in achievement between the experimental and control groups in the posttest, the groups' mean scores were compared using the t-test for independent samples. As shown in Table 4, there is a statistically significant difference between the two groups' posttest scores with respect to CECAT (t (99) = 10.192, p = 0.001). The difference in posttest mean scores for the experimental and control groups was very large with a standardized effect size index of 2.06.

The results indicate that teaching with the learning cycle approach was more successful in teaching the selected concepts than using the traditional approach.

Table 4: Results of Independent Samples t-test for the Posttest Scores of Experimental and Control Groups

Variable	Group	N	Mean	SD	t	df	p
Posttest	Experimental	59	21.14	2.240	10.192	99	0.001*
	Control	42	16.07	2.744			

*Significant, since $p < 0.05$

A linear regression analysis was conducted to evaluate the prediction of posttest scores from the type of intervention used. The regression equation for predicting the overall posttest is:

Predicted posttest scores = -5.064 type of intervention + 26.200

The coefficient of correlation between posttest scores and the type of intervention was R = -0.716 which gives a coefficient of determination $R^2 = 0.512$ (t (99) = -10.192, p = 0.001). This implies therefore that approximately, 51.2% of the variance of the posttest was accounted for by its linear relationship with the type of intervention used.

Another purpose of the study was to investigate the effectiveness of the learning cycle approach in teaching several interrelated concepts and a number of different aspects involved in direct current electricity. The t-test for independent samples was used to analyze the two groups' posttest mean scores for the instructional objectives (IOs). As shown in Table 5, the results revealed that the posttest mean scores of students' responses for IO 1 regarding identifying and explaining a short circuit were significantly different between the experimental and control groups.

The results indicate that the posttest mean scores of students' responses for IO 4 and 5 regarding the application of the concept of resistance to a variety of circuits and the interpretation of diagrams on a variety of circuits including series, parallel and combination of the two were statistically significant. For IO 8 and 9 regarding explaining the microscopic aspects of charge flow in a circuit and applying the knowledge that the amount of current is influenced by the potential difference maintained by the battery and resistance in a circuit, there were statistically differences significant between the groups' posttest mean scores. In the IO 10 and 11 regarding applying the concept of potential difference to a variety of circuits including the knowledge that the total potential difference in a series circuit is the sum of all the individual potential differences whiles in a parallel circuit the total potential differences is equal everywhere in the circuit and combining the concepts of current and potential difference to a variety of circuits, there were statistically differences significant between the groups' posttest mean scores.

Table 5: Statistics of Posttest Mean Scores in the Instructional Objectives (IOS) for the Experimental and Control Groups

Instructional Objectives	Groups	Posttest Mean	SD	t	p
IO 1 (2 items)	Experimental	1.58	0.498	3.803	0.001*
	Control	1.14	0.647		
IO 2 (1 item)	Experimental	0.75	0.439	-0.183	0.855
	Control	0.76	0.431		
IO 3 (1 item)	Experimental	0.81	0.393	0.343	0.742
	Control	0.79	0.415		
IO 4 (3 items)	Experimental	1.83	0.813	2.897	0.005*
	Control	1.33	0.902		
IO 5 (3 items)	Experimental	2.36	0.713	5.919	0.001*
	Control	1.52	0.671		
IO 6 (1 item)	Experimental	0.58	0.498	1.179	0.241
	Control	0.45	0.550		
IO 7 (2 items)	Experimental	1.31	0.676	1.948	0.054
	Control	1.05	0.623		
IO 8 (4 items)	Experimental	2.61	0.910	2.412	0.018*
	Control	2.14	1.026		
IO 9 (3 items)	Experimental	2.51	0.728	2.109	0.037*
	Control	2.19	0.773		
IO 10 (7 items)	Experimental	4.88	0.911	6.669	0.001*
	Control	3.52	1.131		
IO 11 (3items)	Experimental	1.93	1.158	3.514	0.001*
	Control	1.19	0.862		

*Significant, since $p < 0.05$

The results showed that the learning cycle approach was more effective for teaching most of the concepts indicated in the instructional objectives than the traditional method of teaching. Contrary, results of the analysis revealed that the posttest mean scores for the groups on IOs 2, 3, 6 and 7 were not statistically significant.

DISCUSSION

The purpose of this study was to compare the learning cycle approach to the traditional teaching approach on senior secondary school form three (3) science students' understanding of selected concepts in direct current electricity. As seen in Table 2, although there is no statistical significant difference between the mean scores of students in the experimental and control groups the experimental regarding the pretest, after intervention as seen in Table 4, a statistically significant difference was found between the two groups mean scores in terms of posttest. The results of the posttest indicated that the students taught by using the learning cycle method were more successful than the students taught by the traditional approach. This finding is consistent with the view claiming that correct use of the learning cycle accomplishes effective learning of science concepts (Lawson, 2001). It also supports the findings of Ates (2005) and Yilmaz and Cavas (2006) that the learning cycle method is more successful in teaching concepts in electricity than the traditional method.

The study also investigated the effectiveness of the learning cycle approach and the traditional approach in teaching the interrelated concepts and a number of different concepts involved in direct current electricity. The findings show that the learning cycle approach is more effective for teaching the concepts of short circuit, resistance in circuits, circuit combinations, charge flow in circuits, and potential difference across circuit elements more successfully than the traditional approach. However, the findings showed that there was no statistically significant difference between the learning cycle group and the traditional approach group students' understanding of some of the concepts. These concepts were connections in circuits, identification of complete circuits, battery as a source of energy and conservation of current in circuits.

These findings support the findings of Ates (2005) that the learning cycle approach is more effective in teaching most of the interrelated concepts and a number of different concepts involved in direct current electricity than the traditional approach.

CONCLUSIONS

The learning cycle approach is more effective for teaching concepts in direct current electricity than the traditional teaching approach. The learning cycle approach is also more effective in teaching most of the interrelated concepts and a number of different aspects involved in direct current electricity than the traditional approach.

Implications for Educational Practice

1. In teaching concepts in direct current electricity, the practice of feeding students with information should be minimized since its effect on students' understanding is not as significant as those instructed with the learning cycle approach where students find out information for themselves.
2. The learning cycle approach which uses inquiry based activities should be encouraged in many physics instructions, since it offers students more opportunities to explore, discuss, challenge and test their pre-existing ideas about concepts before formal instruction.

It is suggested that further research need to be conducted in identifying the shortcomings of the learning cycle teaching approach.

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