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Using Discovery Learning To Enhance The Performance Of Basic Six Pupils In Basic Electronics In Leaders' Academy At Meduma, Kwabre East District In Ashanti Region, Ghana.

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Abstract- This study was conducted to determine the extent to which discovery learning could enhance the performance of Basic Six pupils in Basic Electronics. It is a quantitative action research that employed the One Group Pretest-Posttest research design. The performance of 21 Basic Six pupils in Basic Electronics was obtained after being taken through a five-hour introductory lesson and another five hours of discovery learning. Data collected were analysed using Average of Gains and Paired t-Tests. Results revealed that discovery learning approach is more effective in improving student achievement in Basic Electronics. Also, the experience of doing it by oneself makes it easier to discover and grasp concepts that are even deemed above standard. It was concluded that discovery learning approach is a viable teaching method for enhancing pupils' performance in Basic Electronics. Based on these, it was recommended that teachers adopt the discovery learning approach for teaching Basic Electronics at the basic level and that government and private school proprietors make the needed resources readily available for teachers.

I. Background to the Study

Electronics is the science and engineering of systems and equipment that utilise the flow of electrons in a closed loop referred to as electric circuits. (Maxfield *et al,* 2008). Electric circuits are basic parts of all electronic devices from radio and TV sets to computers and automobiles. They are everywhere, from the working of simple torch, through to how our household works to the gadgets that give us pleasure and help us get things done. Even scientific measurements from physics to biology and medicine, are all made with the use of electric circuits. (Giancoli, 2005). Like air, electronics is everywhere, and for a very longtime basic electronics has featured prominently in the primary school syllabus. Notwithstanding, many methods have been employed in its teaching over these years.

As a way of linking pupils' previous knowledge to the somewhat abstract working of an electric circuit, certain teachers employ the use of analogies. In teaching Basic Electronics, the commonly used analogy is the electronic-hydraulic analogy or drain-pipe theory Nahin (2002), where an electric circuit is likened to water flowing through a hydraulic system. Another is the marbles analogy where electron flow in conductors is likened to marbles in a tube. (Kuphaldt, 2006). All these analogies are believed to help students' learning by providing visualization of abstract concepts, allowing for comparison between the students' real world and new concepts, and by increasing their motivation (Duit, 1991). However, owing to the poor background of most students, the analogies end up creating a foggy misconception that plagues them all through their electronics education.

One other method that is also used is, demonstration. For reasons as lack of laboratories and sufficient materials, most teachers often demonstrate concepts and skills while the learners watch. Sometimes it is done in small groups while others also do a whole class demonstration often with or without short practice sessions. Baah, Assem, Nartey, and Anafo (2018), demonstrated to his class, then called pupils to make demonstrations by themselves. Similarly, Santiago and Abioye (2015) used this practical demonstration method to teach electronics to first year engineering students.

Atsumbe, Owodunni, Raymond, and Uduafemhe (2018) also proposed Collaborative Instructional approach as opposed to Scaffolding. There need be no mention of Receptive Learning. Sadly, some teachers lecture their way through Basic Electronics merely using the diagrams and pictures in the textbooks as evidence of the concepts.

Nevertheless, according to Ausubel (1969), either of these methods, if properly linked to the previous knowledge of the students, can lead to meaningful learning. For instance, an analogy that is made with something all the students could relate to, can be meaningful and foster understanding among the students.

Clearly, many of the traditional methods of teaching could be used when grasping of the concept is being considered. However, the status quo has changed. In the year 2019, the Ministry of Education through the National Council for Curriculum and Assessment (NaCCA), released a new curriculum for the Basic Schools. In this new curriculum, pupils have certain content standards they are to achieve at the end of Strands and Sub-strands. Alongside these are core competencies they are to attain at the end of the same Stands or Sub-strands. Basic Six pupils under Electricity and Electronics (Basic Electronics), are to demonstrate knowledge of generation of electricity, its transmission and transformation into other forms, as the content standard, which formally was the main objective. To achieve this standard, they are to achieve certain indicators, which previously was specific topic objectives. First of all, they are to be able to construct an electric circuit and know the functions of its components. Then, they are supposed to identify the symbols used to represent various components in a given circuit diagram. Aside these, the pupils are to be introduced to science process skills such as planning, observing, manipulating and generalizing. They are also to end up with critical thinking and problem solving, communication and collaboration as the core competencies of learning Basic Electronics. (NaCCA, 2019)

The old methods could help in achieving some of the indicators. For instance, through drills, pupils could be made to recall the functions of the components of basic electric circuits and the symbols that represents them in electric circuit diagrams. Demonstration could also help in achieving the content standard as recommended by Baah *et al.* (2018). However, these methods barely tackle manipulation and generalization, critical thinking, problem solving and the other competencies. For this reason, a new method and line of teaching is required in the teaching of Basic Electronics. There is the need for a method that would not make the pupils living libraries or conformists to the old saying, "Chew, Pour, Pass, and Forget" that has plagued our educational system. Instead, there is the need for a method that can make students understand, retain and apply learnt concepts through critical thinking and problem solving. As a remedy, this study proposes Discovery Learning.

II. Statement of Problem

From the observations and analysis of the tests in basic electronics, about eighty-percent (80%) of the pupils fell short in all the indicators and objectives set for them in the new curriculum and the old syllabus respectively. They could not construct an electric circuit. They could not tell the functions of most components of basic electric circuits. Lastly, they could not identify the symbols used to represent the various components in circuit diagrams. In view of this, the researcher wants to find out how discovery learning can be used to improve the performance of pupils in basic electronics concepts

Purpose of the Study

This study seeks to enhance the academic performance of Basic Six Pupils of Leaders' Academy in basic electronics through discovery learning.

Research Question

This research hopes to answer the following question:

To what extent will discovery learning improve the performance of pupils in basic electronics concept?

Theoritical Framework

According to Bruner (1961), it is an inquiry-based, constructivist learning theory that takes place in problem solving situations where the learner draws on his or her own experience and existing knowledge to discover facts and relationships and new truths to be learned.

Discovery learning involves students working together in small groups (Rowe, 2004), discussing processes and outcomes while educators are serving as 'experts' and facilitators. This way of learning is active rather than passive; learning is process-oriented rather than content-oriented; failure is important; feedback is necessary; and understanding is deeper (Castronova, 2000).

To anticipate misconceptions or incomplete or unorganized knowledge, discovery learning is developed by integrating guidance in learning activities. Guided discovery learning is still centred on students and the teacher acts as a guide giving limited guidance, because if there are too many guidelines for discovery, then learning will be similar to direct learning, and thus learning loses its benefits (Yang et al., 2010).

The educator devises a series of statements or questions that guide the learner, step by logical step, making a series of discoveries that leads to a single predetermined goal. In other words, the educator initiates a stimulus and the learner reacts by engaging in active inquiry, discovering the appropriate response. By actively doing and consequently discovering facts or concepts, the learner will understand and thus, remember the subject matter. The teachers must also ask questions that may lead to the discovery (Mayer, 2003; Rowe, 2004), give guidance, encouragement and feedback (Burden & Byrd, 2003; Fasko, 2000; Villanueva, 1976).

III. Literature Review

Effects of Discovery Learning on Retention of Facts

Speaking on *The Act of Discovery*, Brunner (1961), while explaining the importance of discovery learning he labelled '*The Aid to Memory Processing*', argued that, the very attitudes and activities that characterizes 'figuring out' or 'discovering' things for oneself also seem to have the effect of making material more readily accessible in memory.

To him, the best was way to enhance retention of memory is by letting learners discover things on their own; including already known facts. In simple terms, a student is more likely to remember ideas, concepts, etc. that they discovered for themselves rather than through expository lessons.

Clear evidence of this fact lay in the study of Dukomalamo (2019). Using Discovery Learning model, a study was conducted on the cognitive learning outcome and learning activities among students at class VIII-4 of SMP Negeri 4 Kota Ternate in the subject of the Structure and Function of Plant Tissues, and found an improvement.

Balim (2008) also reached the same conclusion. Also employing Discovery Learning, studies were made on students' success and inquiry learning skills in a quasi-experimental research design with a pre-test and post-test control group to study fifty-seven 7th graders during the spring term of the 2006-2007 academic year. At the end of the study, a significant difference in favour of the experimental group over the control group regarding the average of academic achievement, scores on retention of learning, and perception of inquiry learning skills scores was found, both on cognitive and affective levels.

Bruner (1961), also concluded his explanation on the point, '*The Increase in Intellectual Potency'* by saying that, when one takes part in discovering information for themselves, it teaches them to acquire the information in a way that makes the information more readily viable in problem solving.

This is evident in Akinbobola (2015). The study assessed the enhancement of transfer of knowledge in physics through the use of effective teaching strategies in Nigerian senior secondary schools. Non-randomized pretest-posttest control group design was adopted for the study. A total of 278 physics students took part in the study. Transfer of Knowledge Test in Physics (TKTP) with the internal consistency of 0.76 using Kuder Richardson formula 21, was the instrument used in collecting data. Analysis of Covariance (ANCOVA) and t-test were used to analyse the data. In the end, results showed that guided discovery was the most effective in facilitating students' transfer of knowledge in physics.

Effects of Discovery Learning on Critical Thinking and Problem-solving

Critical thinking is defined as the intellectually disciplined process of actively and skilfully conceptualizing, applying, analysing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action" (Scriven and Paul, 2007). Critical thinking skills are important because they enable students to deal effectively with social, scientific, and practical problems (Shakirova, 2007). Simply put, students who are able to think critically are able to solve problems effectively.

Problem solving also is about the use of logic, often including simple mathematics, to address real-life situations and aid decision making. (Butterworth and Thwaites, 2013). Problem solving and decision-making present a higher order of challenge than simply knowing or recalling or understanding facts (Butterworth and Thwaites, 2013). To be able to communicate their knowledge to others and help them to collaborate with others also requires the pupils having complete control over the subject matter; preferably in their own words, rather than regurgitating that which they have been fed (Bruner, 1961).

According to Bruner (1961), one sure way of acquiring these competencies is through discovery learning. To him, as per his explanation on the importance of discovery learning titled *'The Shift from Extrinsic to Intrinsic Rewards'*, a child would manipulate his environment more actively and achieve his gratitude from coping with problems when the task is their own rather than a matter of matching environmental demands.

The child taught through discovery would seek to gain control of his environment and would value success and failure as information, instead of reward and punishment. Thus, the act of Curiosity leading to Critical thinking and Problem-solving would build up in students as they discover things for themselves.

Evidence of the effectiveness of discovery learning (problem solving method) to improve critical thinking and problem solving lay in the work of Mustofa, Didek and Desmira (2017). Discussing the findings after taking the first grade of Installation Technique of Electricity Power at SMK Negeri 2 Pandeglang through Basic Electronics learning module based on problem solving, they stated after t-test analysis showed significant improvement between the pretest and the posttest and declared the module eligible for use that, discovery learning directs students to do troubleshooting. It also directly trains them to think critically and improves students' learning outcomes.

Amabile (1988) also attests to this effect of discovery learning. She interviewed R&D scientists on the qualities of problem solvers that promote creativity and found that 40% of the scientists mentioned Self-motivation as a key factor that promotes creativity. Another 38% mentioned Special Cognitive Abilities (special talents in the problem solver's particular field as well as general problem-solving abilities). A further 34% mentioned risk-orientation (which according to Bruner originates or is strengthened by discovery learning) with the only mention better than these being a 41% of personal traits like persistence, curiosity, energy and intellectual honesty; some of which are benefits of discovery learning.

Furthermore, Bruner (1961) on the importance of Discovery Learning titled *'Learning the Heuristics of Discovery'* concluded by saying, "I have never seen anybody improve in the art and technique of inquiry by any means other than engaging in inquiry."

By extension, what this point and the reason for choosing discovery learning means is that, we cannot just have geniuses who would one day take on the problems of their environments and turn them to workable solutions without first training them on how to discover solutions from problems as is done in discovery learning.

Bredderman (1982) supports this assertion with the results of a meta-analysis of 15 years of research on activity-based science programs. This synthesis of research was based on approximately 57 studies involving 13, 000 students in 1, 000 classrooms. All of the studies involved comparing activity-based programs (the Elementary Science Study, Science-A Process Approach, or the Science Curriculum Improvement Study) with comparable classrooms using a traditional or textbook approach to science teaching. A variety of student performance measures were analysed. The most dramatic differences were found in science process skills where the students in activity-based programs performed 20 percentile units higher than the comparison groups.

The study further shows that students in discovery learnings programs scored higher than the control groups in the following measures (ranked from largest to smallest differences): creativity, attitude, perception, logic development, language development, science content, and mathematics; to the extent that students who were disadvantaged economically or academically gained the most from the activity-based programs.

As part of the reflections of using discovery learning in Chinese universities, Wang (2016) also concluded that, discovery learning fully mobilizes the activeness of the students, and stimulates internal learning motivation. At the same time, it activates the class atmosphere and gain a well effect. Also, it cultivates students' interest to explore and enhance the ability of observation, thinking and in summary, developing their potential.

IV. Methodology

This study was conducted using the action research approach. The population of this study was drawn from the 2019/2020 Basic Six class of Leaders' Academy at Meduma in the Kwabre East District. The school has only one basic six class with a total number of 26 registered pupils. Out of these, 12 are girls and 14 boys. The study was conducted with 21 pupils, all of whom were conveniently sampled. This sampling method was used because the school has only one basic six class. Also, owing to the fact that most of the teaching and learning activities in the school do not involved hands on practice, so all the 26 pupils were therefore sampled. The tools that were employed in this study was test. Written tests were administered before and after the intervention. Four tests were conducted each. The answers from the pupils were marked and recorded as the respective individual Pretest and Posttest results of the study, and for analysis. In Question 1 of Test 1, they were asked to identify five symbols that represent some components of basic electric circuit for 10 marks. The second question of Test 1 required the pupils to design an electric circuit that would light two LEDs for a total of 10 marks. In Test 2, the pupils were given some basic electronics components and asked to state their functions for a total of 10 marks. Test 3 was a repeat of Question 1 of Test 1, however, with different symbols. Finally, in Test 4, the pupils were provided with some electronic components and asked to design an electronic circuit that works with them for 10 marks.

The whole research took three weeks and was done using the One Group Pretest-Posttest design. A pretest was conducted to prove the perceived problem. The first phase of the intervention began the ensuing week then the second phase the following week, before the posttest was taken. The data collected from the study were compiled into tables. Analysis on the data were done using Microsoft's Excel, 2019 version. The analysis on these data included comparisons of the means of the Pretest and Posttest scores using Normalized Gain analysis and Paired t-Tests analysis.

V. Result and Discussion

Research Question: To What Extent Can Discovery Learning Enhance the Performance of the Pupils in Basic Electronics?

To test their critical thinking and problem-solving abilities, the pupils were given two tests. The first required them to come up with their own circuit to light two LEDs while the second employed them to design a working electric circuit from a given set of electric components. The pupils' performance in the pretest and posttest is shown in Table 2.

Table 1: Pretest and Posttest Scores on Critical Thinking and Problem Solving (N=21)

Pupils	Pretest			Posttest		
	Design Electric Circuit/10 (Question 2, Test 1)	Design Electric Circuit/10 (Test 4)	Total/20	Design Electric Circuit/10 (Question 2, Test 1)	Design Electric Circuit/10 (Test 4)	Total/20
1	0	3	3	5	5	10
2	2	3	5	7	5	12
3	0	2	2	8	8	16
4	1	4	5	4	7	11
5	2	1	3	3	3	6
6	0	1	1	10	8	18
7	0	1	1	3	5	8
8	6	9	15	10	10	20
9	4	0	4	10	8	18
10	0	1	1	7	8	15
11	2	6	8	10	8	18
12	7	3	10	10	10	20
13	3	1	4	9	8	17
14	2	5	7	10	7	17
15	0	0	0	7	7	14
16	2	1	3	7	8	15
17	2	2	4	4	0	4

18	2	1	3	7	5	12
19	2	2	4	3	4	7
20	4	2	6	10	10	20
21	3	5	8	10	5	15

The table shows that thirteen pupils scored below 5 marks in the pretest. Six pupils also scored between 5 and 10 marks while only two pupils scored at least half of the total marks. This however changes in the posttest. Three pupils scored full marks while a total of twelve pupils scored 15 marks and above. Five pupils scored between 10 and 14 marks while four pupils scored below 10 marks.

A normalized gain analysis on the pretest and posttest scores yielded an average normalized gain (**g**) of 0.63 as seen in Table 3, which is a medium gain as 0.30 < **g** < 0.70.

Table 2: Average Gain of Pupils on Critical Thinking and Problem Solving

Pupils	Total Pretest Score	Total Pretest Score %	Total Posttest Score	Total Posttest Score %	Individual Gain
1	3	15	10	50	0.41
2	5	25	12	60	0.47
3	2	10	16	80	0.78
4	5	25	11	55	0.40
5	3	15	6	30	0.18
6	1	5	18	90	0.89
7	1	5	8	40	0.37
8	15	75	20	100	1.00
9	4	20	18	90	0.88
10	1	5	15	75	0.74
11	8	40	18	90	0.83
12	10	50	20	100	1.00
13	4	20	17	85	0.81
14	7	35	17	85	0.77
15	0	0	14	70	0.70
16	3	15	15	75	0.71
17	4	20	4	20	0.00
18	3	15	12	60	0.53
19	4	20	7	35	0.19
20	6	30	20	100	1.00
21	8	40	15	75	0.58
			Average of Gain =		0.63

The pretest and posttest scores were further analysed with Paired t-Test to see whether the improvement was significant. Table 4 shows the results of the analysis.

Table 3: Paired t-Test Result on Pretest and Posttest on Critical Thinking and Problem Solving

	Posttest Scores	*Pretest Scores*
Mean	13.95238095	4.619047619

Variance	23.14761905	12.34761905
Observations	21	21
Pearson Correlation	0.445456322	
Hypothesized Mean Difference	0	
Df	20	
t Stat	9.461866454	
P(T<=t) one-tail	3.97677E-09	
t Critical one-tail	1.724718243	
P(T<=t) two-tail	7.95354E-09	
t Critical two-tail	2.085963447	

From Table 4, the analysis on pretest (*M = 4.62, SD = 3.51*) and posttest (*M =13.95, SD = 4.81*) on critical thinking and problem-solving abilities in designing and construct basic electric circuits shows a significant improvement, $t(20) = 9.46$, $p < .001$.

By inference, it can be stated that, discovery learning has improved the critical thinking and problem-solving abilities of Basic Six pupils of Leaders' Academy in Basic Electronics such that they can design and construct basic electric circuits.

The effects of discovery learning on critical thinking and problem solving was also studied in the ability of the pupils to retain facts about the functions of basic electric components and electric circuit symbols. This was done by asking the pupils to state the functions of some basic electric component as well as identify some electric circuit symbols. The performance of the pupil in the pretest is shown in Table 5.

Table 4: Pupils' Pretests Scores on Retention of Facts (N=21)

Pupil	Electric Circuit Symbols /10 (Question 1, Test 1)	Electric Circuit Symbols /10 (Test 3)	Functions of Electronic Components /10 (Test 2)	Total / 30	Percentage
1	2	0	0	2	6.67
2	0	2	2	4	13.33
3	2	2	4	8	26.67
4	2	4	1	7	23.33
5	0	0	0	0	0.00
6	0	0	0	0	0.00
7	2	0	0	2	6.67
8	7	8	1	16	53.33
9	7	6	5	18	60.00
10	2	0	1	3	10.00
11	4	3	3	10	33.33
12	3	6	1	10	33.33
13	2	6	1	9	30.00
14	4	0	3	7	23.33
15	4	0	3	7	23.33
16	3	2	2	7	23.33
17	1	0	3	4	13.33
18	5	8	3	16	53.33
19	0	2	0	2	6.67

20	2	2	2	6	20.00
21	5	4	3	12	40.00

Table 5 shows that no pupil scored above 20 marks. Six pupils scored more than half of the full marks. Seven pupils scored between 6 and 10 marks while the remaining eight pupils scored below 5 marks.

Table 5: Pupils' Posttests Scores on Retention of Facts (N=21)

Pupil	Electric Circuit Symbols /10 (Question 1, Test 1)	Electric Circuit Symbols /10 (Test 3)	Functions of Electronic Components /10 (Test 2)	Total / 30	Percentage
1	10	8	10	28	93.33
2	10	6	7	23	76.67
3	8	8	7	23	76.67
4	10	8	6	24	80.00
5	4	4	1	9	30.00
6	8	8	9	25	83.33
7	10	10	6	26	86.67
8	10	10	10	30	100.00
9	10	10	10	30	100.00
10	10	10	7	27	90.00
11	10	8	8	26	86.67
12	10	10	6	26	86.67
13	8	8	7	23	76.67
14	10	6	10	26	86.67
15	8	10	7	25	83.33
16	6	10	5	21	70.00
17	10	2	9	21	70.00
18	10	10	10	30	100.00
19	6	0	5	11	36.67
20	10	10	10	30	100.00
21	8	10	10	28	93.33

Table 6 shows the marks of pupils in the posttest. Four pupils scored full marks while a total of eleven pupils scored above 25 marks. Eight pupils scored between 21 and 25 marks while only two pupils scored below 15.

The pretest and posttest scores were analysed to see how much each pupil and the overall class had improved. The results of the analysis of gains is presented in the table below.

Table 6: Average Gain of Pupils scores on Retention of Facts (N=21)

Pupil	Pretest Score %	Posttest Score %	Individual Gain
1	6.67	93.33	0.93
2	13.33	76.67	0.73
3	26.67	76.67	0.68
4	23.33	80.00	0.74

5	0.00	30.00	0.30
6	0.00	83.33	0.83
7	6.67	86.67	0.86
8	53.33	100.00	1.00
9	60.00	100.00	1.00
10	10.00	90.00	0.89
11	33.33	86.67	0.80
12	33.33	86.67	0.80
13	30.00	76.67	0.67
14	23.33	86.67	0.83
15	23.33	83.33	0.78
16	23.33	70.00	0.61
17	13.33	70.00	0.65
18	53.33	100.00	1.00
19	6.67	36.67	0.32
20	20.00	100.00	1.00
21	40.00	93.33	0.89
	Average of Gain =0.78		0.78

Some of the pupils recorded gain of 1.00. Two pupils recorded gain less than 0.35. The average normalized gain (**g**) obtained by the class however was 0.78. According to Hake (1998) this represents a high gain as **g** > 0.70.

To see whether the change in the pretest and posttest scores was significant, the mean pretest and posttest scores were analysed by means of Paired t-Test analysis. The result is shown in Table 8.

Table 7: Paired t-Test Analysis of Pupils' Pretest and Posttest Scores 0n Retention of Facts

	Posttest Scores	*Pretest Scores*
Mean	24.38095238	7.142857143
Variance	30.74761905	26.92857143
Observations	21	21
Pearson Correlation	0.571432426	
Hypothesized Mean Difference	0	
Df	20	
t Stat	15.86559956	
P(T<=t) one-tail	4.25738E-13	
t Critical one-tail	1.724718243	
P(T<=t) two-tail	8.51477E-13	
t Critical two-tail	2.085963447	

From the Table, the analysis on the pretest (*M = 7.14, SD = 5.19*) and posttest (*M = 24.38, SD = 5.54*) on stating the functions of basic electric components as well as identify the symbols that represents them in electric circuit diagrams, indicates a significant improvement in pupils' performance, $t(20) = 15.87$, $p < .001$.

It is therefore safe to say that discovery learning has improved the ability of Basic Six pupils of Leaders' Academy to retain learned facts about the functions of basic electric components as well as their ability to identify the symbols that represents them in electric circuit diagrams.

VI. Conclusion

This action research was done to find out the extent to which Discovery Learning can improve the performance in Basic Electronics of Basic Six pupils of Leaders' Academy. After careful examination and analysis of the results, which is included impressive averages of gains, very significant calculated t-value from paired t-Test analysis, it can be concluded that Discovery learning can improve and is effective in improving the performance in Basic Electronics. In addition, it is effective for leading pupils to discovery of facts that otherwise may be withheld from them or would not have been taught to them for reasons as scaffolding and others.

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