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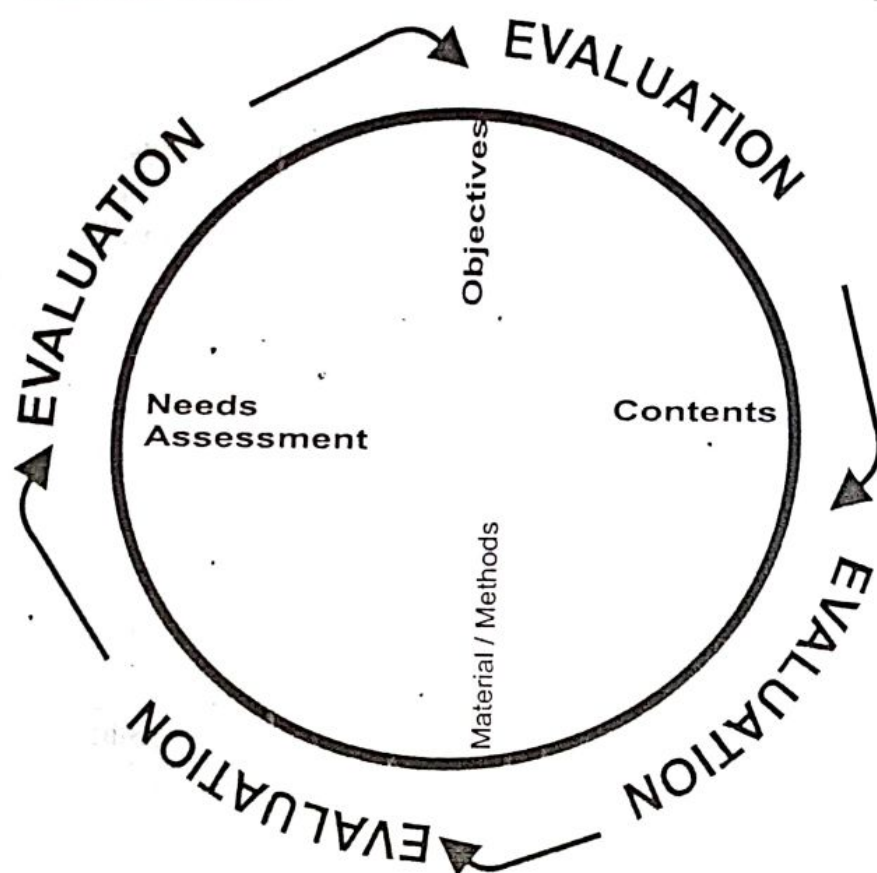


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Effects of the Use of Vee-diagram on Senior School Students' Performance in Physics in Ilorin, Nigeria

By

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Abstract

The present study used Vee-diagram as an instructional tool in classroom settings. The objectives of this study were to: (i) determine the effect of the use of Vee-diagram on students' performance in Boyle's law; (ii) examine the influence of performance levels on students when taught Boyle's law using Vee-diagram and (iii) determine the interaction effect of performance level on students' performance in Boyle's law. The study was a 2 x 3 pretest, posttest, quasi-experimental, non-equivalent and non-randomized control group design. It involved 77 senior secondary school two students in Ilorin, Kwara State, Nigeria. A researcher-designed Physics Metacognitive Conceptual Understanding Performance Test (PMCUPT) was used to collect data for the study. Mean gain scores were used to answer the three research questions raised in the study. *t*-test analysis was used to test hypothesis one and three. Analysis of Covariance (ANCOVA) was employed to test hypothesis two formulated for the study. Major findings of the study showed that there was a significant difference in the performance of physics students exposed to Vee-diagram and those who were not exposed to Vee-diagram, there was a significant difference in the performance of physics students taught Boyle's law using Vee-diagram based on performance levels and there was no significant interaction effect of Vee-diagram on students' performance level when taught Boyle's law.

Introduction

Science according to Abimbola and Omosewo (2013) is a means of investigation that required a variety of unique instructional methods, that is, instructional methods that are usually intended at overcoming obstacles to excellence in students' learning. Musa (2014) associated excellent learning of science concepts to be predominated by the use of student-centered teaching methods/strategies that is aimed at fostering students' performance. Omosewo

(2008) and Opera and Oguzor (2011) both in separate research works viewed science as practical experiences that leads to formulation of ideas in order to understand learning procedure, instructional nature as well as the body of knowledge it incorporated such as in biology, chemistry and physics. Oladajo, Olosunde, Ojebisi, and Isola (2011) attributed the study of physics as an important subject in the secondary school curriculum that helps learners to apply principles, acquired knowledge and skills to construct appropriate scientific expedients from available resources and prepares learners for scientific and technological vocations. Akanbi (2013) and other research experts in physics education such as Okebukola (1992), Okere (1996) and Dramola and Omosewo (2012) revealed that poor performances in physics may be attributed to a number of fundamental reasons such as shortage of science teachers in quality and quantity, inadequate laboratory equipment and facilities, shortage of suitable physics textbooks, inappropriate teaching methods used in teaching, etc.

To address problems of poor performances in physics education, Abdullah, Malago, Buntu and Thalib, (2013); Mutai, Changeiywo and Okere (2014) advanced that students' performance is improved in physics learning through logical thinking, thinking closely related to higher order cognitive skills. These educators established that the objective of learning is to develop higher order thinking skills by providing students with problem solving workouts built on metacognition.

The use of metacognitive tool such as Vee-diagram is among measures to attaining educational objectives stems from the information processing theory of learning and also included the idea of meaningful learning presented by Ausubel in 1966 (Novak & Gowin 1984). According to Ausubel's learning theory, knowledge is organized in propositional network (see figure 1) with each individual's network unique due to each unique experience (Calais, 2009; Safdar, Hussain, Shah & Tasnim, 2013).

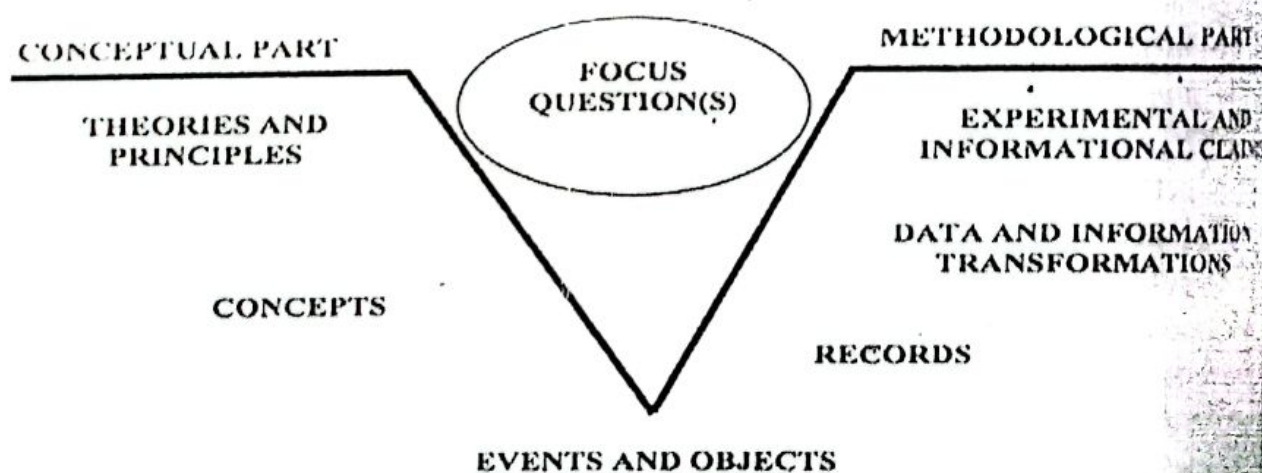


Figure 1: Epistemological Elements of Gowin's Vee-diagram

Source: Novak and Gowin (1984).

The Vee diagram distributes conceptual (thinking) on the left from the methodological (doing) elements of inquiry on the right. Both sides vigorously correlate with each other through the use of the focus question(s) that directly communicates to events and/or objects. Epistemic elements are ordered around the Vee diagram, and represent mechanisms that form the structure of some part of knowledge required to create a new meaning. The conceptual side includes philosophy, theory, principles and concepts all of which are related to each other to the events. On the methodological side of the Vee, records of these events are transmuted into graphs, charts, tables and so forth and become the basis for taking knowledge and value claims.

Simon (2006) claimed that the Vee-diagram as instructional tool is used in believing meaningful learning as a way to aid in the understanding of meaningful relationships among events and processes, or objects under study. Likewise, Scherger (2005), Alvarez and Risko (2007) and Safdar, Hussain, Shah and Anjum (2013) associated the use of Vee-diagram as teaching tool in education is to help students integrating learning style through events, record taking and data transformation.

The teaching of Boyle's law as a concept is chosen in the present study because of chief examiner's reports in WASSEC of 2009, 2010 and 2012 where conceptual and reasoning difficulties on pressure, volume and temperature relationship were identified. The chief examiners' report of 2013, 2014 and 2015 also revealed low percentage in the number of those that attempted questions related to Boyle's laws and inability of those that answered these questions to show efficiencies in problem solving skills.

Dispositions on different variables considered in several studies have revealed the influence these variables must have had in such studies. The present study considered performance level and interaction effect of the tool as moderating variables to determine if they could have effects on senior school students' performance. Several studies on performance level have showed that there is disparity in learner's ability to perform a specific task. Aiyedun (1995) asserted that a significant difference existed in the achievement of low, medium and high scoring students. Ekpenyong and Inyang (2000) conducted a study on effects of problem solving instructional strategy on senior secondary school students' attitude toward mathematics. The study found out that significant difference existed between the three levels of scorer. The study further revealed that high scoring students benefitted more followed by the medium scoring

students and low scoring students. The study of Sunday, Akanmu and Fajemidagba (2014) reposition memory, intelligence and cognitive views in line with differences in ability level suggested the use of appropriate instructional methods to close the wide gap in learning ability of the learner.

Statement of the Problem

Investigations on several studies have showed that students studying physics at all stages of education have been on the decline due to poor performance in physics examinations (Oladajo, Olosunde, Ojebisi, & Isola 2011). Neira and Soto (2013) and Wambugu and Changeiywo (2008) particularly revealed that of all the sciences, physics is the subject in which performance have been on the decline in most secondary schools education in the recent past. These educators attributed this to inadequate excellent physics teachers with poor instructional methods to teaching physics concepts. Other researchers such as Czprok and Popescu (2014), Mutai, Changeiywo and Okere (2014) and Safdar, Hussain, Shah and Tasnim (2013) reported that physics is a difficult subject to learn with a glaring assertion on the failure of instructional strategy put into use in various physics classrooms as major cause.

Gowin's Vee-diagram as a very useful teaching tool has been extensively used in many countries like United states of America (Novak & Gowin, 1984), Finland (Ahlberg, 2005), Australia (Afamasaga-Futai, 2008), Venezuela (Ramírez, Aspén, Sanabria & Tellez, 2008), Kenya (Mutai, Changeiywo & Okere 2014), Pakistan (Safdar, Hussain, Shah & Tasnim, 2013), Romania (Czprok & Popescu, 2014), South Africa (Ramahlape, 2004) and Nigeria (Okebukola, 1992) among others in addressing problem of instructional methods used in laboratory lessons and general classroom situations in bringing about meaningful learning. Ahlberg (2005), Novak and Gowin (1984), Alvarez and Risko (2007), Afamasaga-futai (2008), Danmole (2009), Mutai, Changeiywo and Okere (2014) all contended that Vee-diagram is an instructional tool that take into consideration insufficiency in development, low distinctive intelligence, and the quality of the instructional sequencer.

Findings of Okebukola (1992) in a study about the concept map and Vee-diagram revealed that the concept map method was found easy in principles by the teachers who participated in the study while the Vee-diagram was considered by these teachers to be difficult to learn and apply. Findings of Mutai, Changeiywo and Okere (2014) revealed in a study carried out in physics classrooms in Kenya on the effects of Gowin's Vee-diagram strategy on students' conceptual indulgent and metacognition among secondary schools in UasinGishu County. Mutai, Changeiywo and Okerestudy attributed poor

instructional methods to students' performance. The use of Vee-diagram in the present research study serves as an instructional tool in a classroom setting to bridging the gap between students with different learning competences and observes metacognitive learning difference among senior school students.

Purpose of the Study

The main purpose of this research study was to determine the effects of the use of Vee-diagram on senior secondary school students' performance in physics in Zaria, Kwara state, Nigeria. Specifically, the study determined;

1. the effect of the use of Vee-diagram on students' performance in Boyle's law, and
2. the influence of performance level on students' performance when taught Boyle's law using Vee-diagram.
3. the interaction effect of Vee-diagram and performance level on students' performance in Boyle's law.

Research Questions

The following research questions were answered:

1. what is the effect of the use of Vee-diagram on students' performance when taught Boyle's law?
2. do students' performance level have any influence on students' performance when taught Boyle's law using Vee-diagram?
3. do there exist any interaction effect of performance level on students' performance in Boyle's law using Vee-diagram?

Research Hypotheses

The following null hypotheses formulated were tested at the 0.05 level of significance:

H₀₁: There is no significant difference in performance of students taught Boyle's law using Vee-diagram and those taught not using Vee-diagram.

H₀₂: There is no significant difference in performance of students when taught Boyle's law using Vee-diagram on the basis of performance level.

H₀₃: There is no significant difference on the interaction effect of Vee-diagram and performance level on students' performance in Boyle's law.

Scope of the Study

The study was carried out on the effects of the use of Vee-diagram on senior school students' performance in physics towards knowledge acquisition using Gowin's Vee-diagram epistemological elements among senior secondary

school two students in Ilorin West, Kwara State, Nigeria. Two co-educational public schools in Ilorin West local government council area of Kwara state with intact classes of SSII students were purposively selected. The content of instructions was focused on Boyle's law. Performance level was considered as a moderating variable.

Significance of the Study

The result of this study may be of significance to the following stakeholder in the field of science education: students, physics teachers, curriculum planners and developers, researchers etc. Findings of this study will bring to limelight the pedagogical use of Vee-diagram in physics classroom particularly on the teaching of Boyle's law which will improve student's insight on knowledge structure and knowledge construction in Boyle's law. The use of Vee-diagram could in this respect broaden the content knowledge of the teacher involved, i.e. it could contribute to epistemic knowledge pattern and claim where Vee-diagram serves as alternative to practical class.

Research Method

This study adopted an experimental research design of the quasi-experimental type. The research design used in this study was a pretest, posttest quasi experimental, non-equivalent and non-randomized control group design. This study adopted the $2 \times 2 \times 3$ factorial design.

The population for this study comprises of all the senior school students in Ilorin, Nigeria. The sample was drawn from two purposively selected public senior secondary schools (two co-educational schools) with an intact class of seventy seven (77). The researchers considered students' performance level. The students were grouped into three different score levels (low 0-49%, medium 50-69% and high 70% upwards).

A physics metacognitive conceptual understanding performance test (PMCUPT) was used to measure students' performance and understanding (in terms of concepts and problem solving ability) in the topic of Boyle's law in principle. The performance test was adapted from past physics WASSCE questions. It consisted of twenty (20) structured questions that measured conceptual, metacognitive and problem solving skills. Lesson plan was developed and used for lesson presentation for the treatment group. The presentation was conducted using the Vee-diagram epistemic components.

To ensure face and content validity of the instruments, PMCUPT items were given to two lecturers in the department of science education, University of

Ilorin and two experienced senior school physics teachers for critique and clarity of words for improvement. Vee-diagram lesson plan was also validated by expert lecturer in test and measurement Item Analysis was considered in order to assess the quality of the items. Item analysis obtained has reliability index of 0.79 after subjecting the question items in PMCUPT to a total 60 students in a co-educational school outside the researcher area of study. Test-retest method was used to obtain a reliability Co-efficient of 0.89 using Pearson Product Moment Correlation Statistics at the 0.05 significance level. Control group was taught using conventional instructional strategy and the experimental group using Vee-diagram technique lesson plan respectively for double lesson periods. After treatment, a shuffled PMCUPT was administered to the respondents as post-test. The pre-test, treatments and posttest activities spanned for two (2) weeks. The data collected from the marked scripts were analyzed against hypotheses raised.

Data Analyses and Results

Research Question One

What is the effect of the use of Vee-diagram on students' performance when taught Boyle's law?

Table 1: Analysis of Mean Gain Scores of Physics Students' Sores in both Experimental and Control Group

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Data Analyses and Results

Research Question One

What is the effect of the use of Vee-diagram on students' performance when taught Boyle's law?

Table 1: Analysis of Mean Gain Scores of Physics Students' Scores in both Experimental and Control Group

Group	Group Statistic	Pretest	Posttest	Mean Gain Score	Diff
Control Group	N	40	40		
	Mean	35.50	50.35	14.85	
	Std Dev.	9.75	5.85		8.58
Experimental Group	N	37	37		
	Mean	35.24	58.68	23.43	
	Std Dev.	10.04	5.59		

Table 1 indicates the mean gain score of students was 8.58. Further analysis was conducted in table 2 to test whether the difference in the mean scores was statistically significant or not.

Research Hypothesis One

There is no significant difference in performance of students taught Boyle's law using Vee-diagram and those taught not using Vee-diagram.

Table 2: Analysis of Physics Students' Scores in Experimental and Control Groups

Group	No. of Respondents	Mean	Std Dev.	df	t-value	Sig.	Decision
Control Group	40	50.35	5.85	75	6.39	.00	Sig.
Experimental Group	37	58.68	5.59				
p<.05							

The result in Table 2 shows t-value = 6.39 with degree of freedom (df) of 75 and p-value of 0.00. Since the p-value was less than 0.05 stated levels; the null hypothesis is accepted. Thus; there was a significant difference in the performance of students taught Boyle's law using Vee-diagram and those taught not using Vee-diagram in favour of the students taught Boyle's law using Vee-diagram.

$$(t_{(2,75)} = 6.39, p < 0.05).$$

Research Question Two

students' performance levels have any influence on students when taught Boyle's law using Vee-diagram?

Table 3: Mean Gain Scores of Physics Students Taught Boyle's law Using Vee Diagram Based on Students' performance Levels

Group	Group Statistic	Pretest	Posttest	Mean Gain Score	Diff
Low	N	11	11		
	Mean	34.36	53.09	18.73	
	Std Dev.	9.16	1.38		5.38
Medium	N	20	20		
	Mean	45.50	58.90	13.40	
	Std Dev.	11.14	3.21		1.23
High	N	6	6		
	Mean	56.00	68.17	12.17	
	Std Dev.	9.12	2.23		

Table 3 revealed the mean gain score of physics students that participated in the posttest administered by the researcher based on students' performance levels. The difference in the mean gain score of the performance levels revealed that low performing students benefited most. Further analysis was conducted in table 4 to determine whether the difference in the mean scores was statistically significant or not.

Research Hypothesis Two

There is no significant difference in performance of students when taught Boyle's law using Vee-diagram on the basis of performance level.

Table 4: Scheffe's Post Hoc of Physics Students Taught Boyle's law using Vee-diagram based on Students' Performance Levels

	(J)	Mean	Std. Error	Sig.	95% Confidence Interval	
Scoring Level		Difference (I-J)			Lower Bound	Upper Bound
Medium		9.27*	1.24	.000	6.10	12.43
Low		15.08*	1.35	.000	11.63	18.52

Medium	High	-9.27*	1.24	.000	-12.43	-6.10
	Low	5.81*	.99	.000	3.26	8.36
Low	High	-15.08*	1.35	.000	-18.52	-11.63
	Medium	-5.81*	.99	.000	-8.36	-3.26

Table 4 revealed the direction of the differences that existed among the three categorized scorers. Scheffe's post hoc analysis in table 4 presented that significance difference exists between the high and low scoring students as the p -values are 0.00, and 0.00 respectively. Also, significance difference exists between the medium and high scoring students and medium and low scoring students with p -value of 0.00 and 0.00 respective. Therefore, there is significant difference in the performance of physics students taught Boyle's law using Vee-diagram on the basis of performance level. The implication is that difference in performance level among the groups has been bridged using Vee-diagram as a tool to improve students' performance in this study with the low scorers benefiting most.

Research Question Three

Do there exist any interaction effect of performance level on students' performance in Boyle's law using Vee-diagram

Hypothesis Three

There is no significant interaction effect of Vee-diagram and performance level on students' performance in Boyle's law

Table 5: Interaction Effect of Vee-diagram of performance Level and Students' Performance in Boyle's law

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	890.19 ^a	5	178.04	23.60	.00
Intercept	103056.41	1	103056.41	13657.57	.00
Scoring	848.46	2	424.23	56.22	.00
Performance	4.68	1	4.68	.621	.44
Scoring * performance	.121	2	.060	.01	.99
Error	233.92	31	7.55		
Total	128509.00	37			
Corrected Total	1124.11	36			

a. R Squared = .79 (Adjusted R Squared = .76)

From Table 5 $F_{(2, 37)} = 0.01$, p -value is 0.99. Since the p -value is greater than 0.05 stated level of significance, the null hypothesis is accepted. Thus; there is

no significant interaction effect of Vee-diagram and students' performance level when taught Boyle's law

Major Findings of the study

Based on the data collected and analyzed for this study, the following findings were obtained

1. There was a significant difference in the performance of physics students exposed to Vee-diagram and those who were not exposed to Vee-diagram at the 0.05 level of significance.

2. There was a significant difference in the performance of physics students taught Boyle's law using Vee-diagram based on performance level at the 0.05 level of significance in favour of low scorers.

3. There was no significant interaction effect of Vee-diagram on students' score level and gender when taught gas law.

Discussion

Based on the findings, the study revealed that there was a significant effect on the use of Vee-diagram teaching tool. This implies that the use of Vee-diagram proved to be effective in teaching of Boyle's law in physics among senior secondary school students. This is in line with the research works of Afamasaga-Akpan (2008), Alvarez and Risko (2007), Mutai, Changeiywo and Okere (2014) and Safdar, Hussain, Shah and Tasnim (2013) who established that the use of Vee-diagram tool improved students' performance against the findings of Ahlberg (2005) and Okebukola (1999) that revealed difficulty of application and time constraints. There was a significant difference in the students' performance since posttest means scores of the low, medium and high scoring students taught Boyle's law using Vee-diagram revealed improvement with low scoring students gaining most. The finding is in agreement with Aiyedun (2005), Smither and Robinson (2007), Ekpenyong and Inyang (2000). However, finding of Sunday, Akanmu and Fajemidagba (2014) contrast this stance.

Conclusion and Recommendations

The use of Vee-diagram in teaching Boyle's law enhanced students' performance in physics significantly. Hence, the study concluded that Vee-diagram as pedagogy tool enhanced students' performance in physics in Ilorin, Nigeria. This implies that the use of Vee-diagram epistemological elements towards teaching improved students' performance. The study likewise concluded that students taught Boyle's law in physics using Vee-diagram benefitted from the study especially low scorers. This implies that the use of Vee-diagram improved

students' performance level in physics.

Based on the findings and conclusions drawn in this study, the following recommendations were proposed:

1. Vee-diagram is an effective instructional tool/strategy; therefore its use should be encouraged for teaching of physics concepts at secondary school level of education.
2. The use of Vee-diagram as a teaching tool should be used by physics teachers to different level of students' performance in different concepts in physics towards bridging performance differences of students learning outcome.
3. Students' preliminary preparation before laboratory applications using Vee-diagrams should be done so as to contribute to interactive learning of concepts among students and helped improve logical and conceptual thinking.

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