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Research Article

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Effects of Inquiry and Concept Mapping Learning Strategies on Student's Performance and Retention in Heat Energy in Basic Science in Junior Secondary Schools

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Abstract This study investigated the 'Effects of inquiry and concept mapping learning strategies on student's performance and retention on heat energy in Basic Science in Junior Secondary school in Ogba/Egbema/Ndoni Local Government Arear, Rivers State. 3 Research questions and 3 hypotheses were raised to give direction to the study. The study was a quasi-experimental research and non-randomized pre-test, post-text design. The study was conducted in public secondary schools in ONELGA in Rivers State. The Sample consisted of 150 JSS2 Basic Science students in two public secondary schools in the study area selected, using random sampling technique. The Basic Science Performance Test (BDPT), with reliability coefficient of 0.84 was used in gathering data. The data obtained were analyzed using mean, standard deviation and analysis of coverage (ANCOVA). The result showed that students taught the concept of heat energy using inquiry learning/teaching strategy performed significantly better than student taught using concept mapping learning and expository teaching strategy. It was also observed that gender had no statistical significant influence on the student's performances given the treatment. There was no significant treatment – gender interaction effects given the student's performances and retention. Consequently, it was recommended among other, that Basic Science teachers should make effective use of inquiry teaching learning strategy in teaching concepts in Basic Science.

Keywords Inquiry Learning, Concept Mapping Learning, Student's Performance, Retention and Basic Science

Introduction

In recent times, there has been complaints from almost all quarters of the Nigerian society that the standard of education has fallen (Adeoye, 2010, Okoronka, 2004, and Omioirhiren, 2002). This situation does not favour Nigeria's move towards developing scientific and technological culture, considering the critical role of science, notably in the area of agriculture, environmental science, medicine, industry, peace, communication and transportation (Okpala 2002). The classroom experience shows that a large number of the junior and senior secondary school science students face considerable difficulty in appreciating and learning scientific concepts in a meaningful way, especially using laboratory activities. This is clear reflection in their poor ability to apply scientific concepts to explain ordinary natural phenomena, make predictions in given situations and solve simple day-to-day problems. Also, many students seem to learn very little science at schools and learning is by rote memory and a large number of students find science to be difficult, boring and not interesting to them (Aniodo, 2008,). Researchers over the years are faced with finding relevant solutions to the problem of poor performance recorded yearly in junior secondary school Basic Science examinations conducted by state ministry of Education (Adeoye, 2010, and Okoronka, 2004). The traditional lecture style known as expository method in teaching Basic Science and Technology courses failed to impart deep seated conceptual understanding of basic science contents in students (Clark and Elen, 2006).

Therefore, it is expected that science teachers should be intellectually and professionally competent to meet the demands of today's world scientific and technological growth and development. To encourage this trend, several authorities advocated through research endeavor, diverse innovative teaching-learning strategies and methods of how students should be reinforced and motivated to learn in order to attain the goals of instructional objectives (Aniodo 2008). If science is to be useful and meaningful to the learners, its study must progress from imagination and abstraction back to concrete life and living through hands-on activities and experiences. That is science is a practical and activity-oriented subject which can be learnt through manipulation of objects and symbols.

Therefore, it is pertinent to look for variables that could be manipulated in order to find their effects on learning outcome and to address the problems of teaching and learning of science in junior and senior secondary schools. Such variables; include inquiry learning and concept mapping learning strategies which are all based on constructivism. Constructivism learning is often associated with pedagogic approaches that promote active learning or learning by doing. Therefore, it is hoped that a better understanding of the effects of mastery and action learning strategies will serve to evolve an effective plan for enhancing students' achievement and retention of concept of heat energy in Basic Science at junior and senior secondary school level.

Inquiry as an instructional strategy involves the attempt to answer questions and seek information. It is a broad strategy and often referred as enquiry, discovery, problem-solving, inductive reasoning, deductive reasoning, and reflective thinking (Romey 2015).

Some aspects of inquiry include: observing nature, predicting outcomes, manipulating variables, analyzing situations and verifying assertions. Inquiry may involve discussing topics with others, reading, conducting field studies and laboratory investigations or all of these during one's attempt to discover new knowledge and to figure things out (Aniodoh 2008).

Inquiry emphasizes active as opposed to passive learning. Inquiry is not limited to question asking only; it is a process of conducting a thorough investigation (Gibson and Keogh 1990). There are basic process skills, which involves inquiry and they include: observing, classifying, measuring, predicting, inferring, defining operationally, formulating hypotheses, communicating, experimenting, controlling variables and interpreting data (Maduabum 1989).

Concept map is a form of circular spatial or web-like display of relationships between concepts, each of which is derived from a central concept with each of the derived concepts displaying a common characteristics of the central concept (Brandwein 2003). It demonstrates how an individual or group builds on previous knowledge to incorporate new concepts into a mental scheme.

It is a teaching and learning strategy that establishes a bridge and sensible learning (Eshiet, 2007). Concept learning is a visual representation of information and can take the form of charts, graphic organizers, timeless or T-charts.

Upon all its advantages and beauty, a concept map lacks full statement on concepts listed on it. There is no full description on the actual nature of each concept and therefore lacking in the provision of full information (Estiet, 2007). It cannot therefore be used effectively by a learner in a study situation.

Statement of the Problem

In spite of all the recognition given to Basic science as capable of laying adequate foundations for further studies in science and as a pivot to technological and economic development, there are wide gaps between curriculum planners, the implementers, that is, Basic Science teachers and what goes on in the classroom. The traditional lecture style mostly used by the science teachers makes students passive in the class. When students are passive during the teaching and learning process as it happens in most of the schools, the students may become bored and inactive in class, perform poorly in examination and get discouraged about the subject. Hence the researcher investigates the use of inquiry and concept mapping in teaching heat energy in Basic Science.

Objective of the Study

The objective of this research, therefore, is to find out the effect of action and mastery learning strategies on the student's performance in heat energy in Basic Science.

Research Questions

The following research questions will guide the study:

1. What differences exist in the mean performance scores of student taught in the concept of heat energy in Basic Science using inquiry learning, concept mapping learning and expository learning.
2. What differences exist in the retention scores of students taught in the concept of heat energy in basic science using inquiry, concept mapping and expository strategies.
3. What differences exist in the performance of male and female students taught in the concept of heat energy in Basic Science using inquiry, concept mapping and expository strategies.

Research Hypotheses

The following hypotheses are formulated to guide the study:

1. There is no significant difference in the mean performance scores of Basic Science Students taught the concept of heat energy, using inquiry concept mapping and expository learning strategies.
2. There is no significant difference in the mean retention scores of Basic Science students taught the concept of heat energy using inquiry, concept mapping and expository teaching learning strategies.
3. There is no significant difference in the mean performance scores of males and female students taught using the concept of heat energy using inquiry, concept mapping and expository teaching learning strategies.

Methodology

The study was designed to investigate the effects of inquiry and concept mapping teaching learning strategies on student's performance and Retention in heat energy in Basic Science. The Sample consisted of 150 JSS 2 Basic Science students. The design for this study is quasi – experimental and it adopted a non – randomized pre – test and Post – test. All J.S.S 2 Basic Science students for 2019/2020 session in Ogba/Egbema/Ndoni Local Government Area of Rivers State constituted the population. Instrument for data collection was Basic Science Performance test (BSPT), made up of 30 items, multiple - choice objective test with 4 options per item. The reliability coefficient was determined using the Kudder Richardson 14 formula and a reliability coefficient of 0.85 was obtained.

Relevant permission was obtained from the principals as well as the Basic Science teachers in each of the schools that were used as research assistants and intact classes were used to avoid interference with the school programme. Two classes were each randomly assigned to experimental group one (47 students), experimental group two (57 students) and (46 students) for control group. The treatment was teaching students in experimental groups 1,2,3 and using inquiry, concept mapping and expository teaching learning strategies for groups respectively. The teachers of the experimental groups were given lesson notes that were validated and these teachers were trained. After training, teaching was done for 3 weeks (two periods a week), all the group (Experimental 1,2, and 3) was taught the concept of heat energy. The Basic Science performance test (BSPT), was trial tested on 40 students of one school (not used for the main study). BSPT items were used both as pre-test and post-test. The test was timed and scripts collected and marked and scored by the researcher. The student's scripts taught by each category of teachers (assistant) was later assembled for Analysis. Descriptive statistics, independent t-test, Analysis of covariance (ANCOVA), and the scheffe multiple comparison test was used for post hoc analysis. All hypotheses were tested at 0.05 level of significance.

Data Analysis And Results

Research question 1: what difference exist among the performance of students in the concept of heat energy in Basic Science when taught using inquiry, concept mapping learning and expository learning strategies?

Table 1: mean and standard deviation of student's Pre-test Post- test scores classified by treatment groups

Treatment Groups	Sample Size	Pre-test		Post-test		Mean Difference
		X	SD	X	SD	
Concept Mapping Learning	45	30.89	6.33	47.02	11.29	16.13
Inquiry Learning	58	44.83	15.17	62.86	15.63	18.03
Expository Learning	47	32.43	6.80	46.47	9.56	14.04

In table 1, the results show that the student taught using inquiry Learning strategy has the best post-test pre-test mean difference (18.03), followed by students taught using concept mapping learning (16.13), and students taught using expository (14.04) in decreasing order.

Research Question 2: What differences exist among the retention of students in the concept of heat in basic Science when taught using inquiry teaching learning strategy, concept mapping learning and expository learning strategy?

Table 2: Mean and standard deviation of students' post-test and retention scores classified by treatment groups

Treatment Groups	Sample Size	Pre-test		Post-test		Mean Difference
		X	SD	X	SD	
Concept Mapping Learning	45	47.02	11.29	35.42	9.23	11.60
Inquiry Learning	58	62.86	15.63	41.91	10.09	20.95
Expository Learning	47	46.47	9.56	39.55	8.31	6.92

In table 2, the results show that the students taught using inquiry teaching learning strategy had the best post-test retention mean difference (20.95), followed by those taught using concept mapping learning strategy (11.60), and those taught using expository learning strategy (6.92) in decreasing rank order.

Research Question 3: What differences exist in the performance scores of male and female students in the concept of heat energy in Basic Science when taught using concept mapping learning, inquiry learning and expository learning strategies?

Table 3: Means and standard Deviation of male and female students performance and posttest score classified by treatment groups

Treatment Groups	Gender	Sample Size	Pre-test		Retention		Mean
			X	SD	X	SD	Difference
Concept Mapping	Male Female	26	48.92	12.20	36.46	9.79	12.46
Learning		19	44.42	9.61	34.00	8.46	10.42
Inquiry Learning	Male Female	25	59.28	15.58	42.76	9.23	16.52
		33	65.58	15.34	41.27	10.79	24.31
Expository Learning	Male Female	21	47.52	10.18	41.24	9.14	6.28
		26	45.62	6.94	38.19	9.17	7.43

In table 3, the results show that the female students taught using inquiry Teaching Learning Strategy has the best Post-test. Pre- test mean difference (24.31), followed by the males also in the Inquiry learning group (16.52), the males in the concept mapping learning group (12.46), the females in expository group (7.43), the males also in the expository learning group (6.28), in decreasing rank order.

Hypotheses one (Ho_1): There is no significance difference between the mean performance scores of basic science students taught the concept of heat energy using Inquiry Teaching Learning Strategy, concept mapping and expository learning strategies.

Table 4: Summary of Analysis covariance (ANCOVA) of students' post – test scores classified by treatment group with pre – test as covariate

Source	Type 111 sum of squares	DF	Mean square	F	Sig.	Decision P≤05 alpha
Pre-test	7215.4	1	7215.04	63.79	0.00	S
Treatment	1564.20	2	782.10	6.92	0.00	S
Error	16512.54	146	113.10			
Total	453908.00	150				
Corrected total	32981.89	149				

R squared of = 0.499 (Adjusted R Squared = 489)

In table 4, the calculated F- Ratio for the effect of instructional methods at DF 2, 149 is 6.92, while its corresponding calculated level of significance is 0.00 alpha. This level of significance is less than .05 in which the decision is based: indicating that there was significant difference in the academic performance of students in the concepts taught using concept mapping. Inquiry and expository learning strategies. With this observation, null hypothesis 1 was rejected. This means that there is a significant difference among the mean scores of students on heat energy in Basic Science based on instructional strategies.

Hypothesis Two (H02): There is no significant difference among the mean retention scores of Basic Science Students taught the concept of head energy using mastery, action and convectional learning strategies.

Table 5: Summary of Analysis of Covariance (ANCOVA) of students' retention scores classified by treatment groups with post – test as covariate.

Source	Type 111 sum of squares	DF	Mean square	F	Sig.	Decision P≤05 alpha
Pre-test	539.16	1	539.16	6.45	0.00	Ns
Treatment	509.31	2	254.66	3.05	0.00	S
Error	12186.01	146	83.47			
Total	244610.00	150				
Corrected total	13800.29	149				

a. R squared = 0.132 (Adjusted R Squared = 0.099).

In table 5, the calculated F – ratio for the effect of instructional methods at DF 2,149 is 3.05. while its corresponding calculated level of significance is .00 alpha. This level of significant difference in the students' retention of the concepts taught using mastery, action and conventional learning strategies. With this observation, null hypothesis 2 was rejected. This means that there is a significant difference among the mean scores of students on heat energy in Basic Science based on instructional strategies.

Hypothesis three ($H0_3$): There is no significant difference among the mean performance scores of students of Basic Science taught the concept of heat energy using concept mapping, Inquiry, and expository strategies based on gender.

Table 6: Summary of Analysis of Covariance (ANCOVA) of male and female students' performance scores classified by treatment groups with pre – test as covariate.

Source	Type 111 sum of squares	DF	Mean square	F	Sig.	Decision P≤05 alpha
Pre-test	7049.98	1	704998	63.61	0.00	S
Treatment	1487.66	2	743.83	6.71	0.00	S
Gender Treatment	34.30	1	34.30	0.31	0.58	NS
	653.70	2	326.85	295	0.06	NS
Gender Error	15848.99	143	110.83			
Total	453908.00	150				
Corrected total	32981.89	149				

a. R squared = 0.462 (Adjusted R Squared = 0.499).

In table 6, the calculated F – value for the main effect of gender given the instructional strategies at df 1.145 is 0.31 while its significant level is 0.58. This significant level is greater than 0.05 alpha in which the decision is based, indicating that the influence of gender on the students' performances was not statistically significant. With this observation, null hypothesis 3 was upheld.

Discussion of Findings

The findings with regard to the effect of inquiry learning, concept mapping learning and expository teaching learning strategies on the students' performances on heat energy in Basic Science showed that there was a significant difference among the mean performance scores of students on heat energy in Basic Science based on instructional strategies. Students taught using inquiry learning teaching strategy performed significantly better than those using concept mapping learning, and expository teaching strategies. The better enhancing effect of inquiry learning on the students' performances could be attributed to its discovery based, problem solving, students centered and engaging activities where learner construct their own knowledge and understanding rather than the teacher. The findings are in agreement with that of Aniodoh (2008) that inquiry learning strategy enhances students' achievement in physics, through joined intellectual effort, problem solving skills, resourcefulness, innovation, creatively, respect for other peoples' view, initiative, curiosity and critical thinking can be created, developed and sustained in classroom.

As regards the retention of the students given the instructional strategies used, the findings indicate that there was a significant difference in the students' retention of the concepts taught using concept mapping, inquiry and conventional learning strategies. Students taught using inquiry learning teaching strategy retained the concepts significantly better than those taught using concept mapping learning, expository teaching learning strategies. This observation could also be attributed to its inquiry based, problem solving, student – centered and engaging

activities where learners constructed their own knowledge and understanding rather than the teacher, and which allowed for the internationalization of the concepts taught. The findings corroborate with that of Romey (2015) in which he pointed that inquiry learning strategy promotes understanding group process, create problem solving and reflection.

On the influence of gender on the students' performances given the instructional strategies used, it was observed that the influence of gender was not statistically significant. This observation indicated that gender is not a strong determinant of students' academic performances. The no significant of gender observed in this study agrees with those of Abubakar and Alao (2010) whose study focused on gender emolument and academic performance of college physics students, revealed that there was no statistical significant difference in academic performance between female and male students.

Conclusion

Based on the findings of the study, it is here by concluded that, the three teaching learning strategies investigated; concept mapping learning, Inquiry learning and expository teaching learning strategies inquiry teaching learning is the most effective.

Recommendations

1. Basic Science teacher should make effective use of Action learning in teaching concepts in Basic Science.
2. Government in conjunction with other professional bodies like STAN Should endeavor to organize and sponsor regular workshops to train science teachers on the use of action learning strategy.

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