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Comparative Effects Of Three Teaching Methods On Students' Performance In Human Blood Circulatory System Concepts And Their Retention Rates

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Abstract

In this study, the authors examined the comparative effects of three teaching methods (lecture-based, analogy-based and animation-based) on students' performance in human blood circulatory system concepts and their retention rates. Quasi experimental design was used for the study. A total of One Hundred and Twenty Three (123) students from Senior High School (SHS) A, Senior High Technical School (SHTS) B and SHS C in the Tano North and South Municipals of Ahafo Region in Ghana were purposively selected and used for the study. Circulatory System Achievement Test (CAT) was developed and used for pre-test, post-test and delayed-posttest. The reliability coefficient of CAT was calculated to be 0.84 using Kudder-Richardson formula 20 (KR 20). Students from SHS A were exposed to the concepts using the traditional lecture-based teaching method while students from SHTS B and SHS C were taught using analogy-based and animation-based teaching methods respectively. Research questions were answered using various statistical tools such as mean, paired t-test, ANOVA, ANCOVA, LSD Post Hoc test, mean plot and box plot. The findings of the study revealed that students who were exposed to analogy-based teaching method exhibited high level of performance [$F(2,120) = 36.55$, $p = .000$] and retention [$F(2,123) = 53.92$, $p < .001$, $\eta_p^2 = 0.48$] of human blood circulatory system than those exposed to the concept through traditional lecture-based teaching method or animation-based teaching method. Based on this finding, it was concluded that analogy-based teaching method was more effective and has the higher potential of improving students' cognitive achievement in human blood circulatory system, and therefore, recommended that science teachers should embrace the use of that method in the teaching and learning of human blood circulatory system concepts.

Keywords: Academic performance, Human circulatory system, Traditional lecture-based teaching, Analogy-based teaching, Animation-based teaching.

INTRODUCTION

Science learning is an essential aspect of basic education that prepares children to stay in a world progressively defined by technological know-how and era (International Council for Science, 2002; Karen, 2010). Biology is crucial or vital to science education. Explaining a biological concept effectively is a cornerstone of success in biology, and curriculum policy documents reecho the significance of this ability (American Association for the Advancement of Science, 2009; Caleb, 2016). Understanding how the body moves material, exchanges oxygen with carbon dioxide and how systems interrelate is fundamental in understanding the human organism. Even though each of us uses our bodies every day, many individuals have an inadequate or limited understanding of how our body systems are interrelated (Ozsevgec, 2007). The American Association for the Advancement of Science [AAAS] (1989) has also stated that a fundamental understanding of the human organism is necessary for achieving the goal of scientific literacy. Students are expected to have a strong understanding of the human body by the time they graduate high school is further reiterated in the *Benchmarks for Science Literacy* and in the middle school and high school. It is the *Next Generation Science Standards* (Achieve, 2013). However, studies have shown that at the undergraduate level have shown that students who enter the medical fields harbour alternative conceptions about the body, specifically the cardiovascular system (CVS) (Ahopelto, Mikkilä-Erdmann, Olkinuora, & Kääpä, 2011; López-Manjón & Angón, 2009; Mikkilä-Erdmann, Södervik, Vilppu, Kääpä, & Olkinuora, 2012). Why is it that understanding the human body is highly stressing at the senior high level but not at the undergraduate level? Many undergraduates in the fields of biology, biochemistry and chemistry may become tomorrow's health professionals, and therefore, need to have a correct understanding of the human organisms to ensure the best possible care for their patients.

It appears the concept of human system and processes in biology concepts such as human circulatory systems are notably difficult to explain to students. Because these concepts are characterized by ramification and complexity of interactions between intangible molecular components that are often represented by abstract models of systems and language with heavy jargon (Tibell & Rundgren, 2010). In general, when expounding natural phenomena, biologists describe mechanisms that regulate the behaviours of complex biological human systems, but explaining these mechanisms in the classroom presents a challenge. Perhaps, due to their complex, intangible, and abstract nature. Nevertheless, permanent and meaningful learning is the target of our educational endeavor. That is, students' academic performance and retention is the priority of any educational system (Iravani & Delfechresh, 2011).

But according to West African Examinations Council's Reports (WAEC Reports), students do not pass well in biology at the West African Senior School Certificate Examination (WASSCE) because of their inability to understand, retain and answer some biological concepts such as human circulatory system and other human system and molecular concepts as these concepts seem to be complex, difficult and abstract in nature. Again, ineffective teaching approaches by biology teachers is also a likely contributing factor to students' poor achievement in biology examination (WAEC, 2014-2018). There is urgency therefore to make human system concepts in biology such as circulatory system explained by biologists more comprehensible to students so we can achieve permanent learning (understanding and retention) (Caleb, 2016).

Some teaching methods and approaches have been proven to be efficient and productive in the teaching and learning of abstract and difficult biological concepts and other science concepts than the conventional lecture method. However, some of these teaching methods are Dramatization, Concept Mapping, Project-based learning, Collaborative, Cooperative, Guided Inquiry and visualization (Ajaja, 2013; Nwagbo & Okoro, 2012; Obomanu, Nwanekezi & Ekineh, 2014). The use of visualization is significant among these approaches (McClean, Johnson, Rogers, Daniels, Reber, Slator & White, 2005). From an educational perspective, visualization helps us to grasp the complexity of biological events that are too small to see with the naked eye (or microscope in the case of biomolecules), or too rapid to experience with our own senses (Jenkinson & McGill, 2013). In other words visualization aids student understanding of complex processes because it assists in the conversion of an abstract concept into a specific visual object that can be mentally manipulated. There are various approaches to visualization in teaching and learning, including analogies (Ameyaw & Kyere, 2018; Chowdhury, 2015; Genc, 2013), computer animations (Bukova-Güzel & Cantürk-Günhan, 2010; Daşdemir & Doymuş, 2012), illustration and graphics (Hibbing & Rankin-Erickson, 2003; Lih-Juan, 2000), and concept maps (Ameyaw, 2015; Novak & Canas, 2008). There are substantial body of literatures which report on the benefits of teaching with analogies or animations and their success in science education. (Paivio, 1990 cited in Bhatti, Shaikh, Rehman, Memon, & Buleidi, 2015; Daşdemir & Doymuş, 2012), or analogy (Chowdhury, 2015; Ameyaw & Kyere, 2018).

In spite of the effectiveness of these two instructional approaches in the teaching and learning of abstract and complex biological concepts and increasing availability of animation as part of textbook packages and analogies used in some textbooks in Ghana, it remains unclear particular in Ghana, the extent to which each of analogy-based and animation-based teaching methods influence biology students' academic performance and retention of the concept of human blood circulatory system. This comparative study therefore seeks to fill this gap.

The purpose of the study is to examine comparative effects of three teaching methods on students' performance in human blood circulatory system concepts and their retention rates guided with the following null hypothesis at 0.05 level of significance:

H_{01}: There is no significant difference in the mean performance scores of students taught human blood circulatory system using *lecture-based, analogy-based and animation-based* teaching methods.

H_{02}: There is no significant difference in the retention rate mean scores of students taught human blood circulatory system using *lecture-based, analogy-based and animation-based* teaching methods.

METHODOLOGY

Sample and Sampling Technique

The accessible population comprised three Senior High Schools in the Tano North and South Municipalities in the Ahafo Region of Ghana. Purposive sampling technique was used to select one intact S.H.S. 2 general science class from each of the schools with a total sample size of 123. The detail of the sample is presented in the Table 1 below:

Table 1: Distribution of students in the Three Instructional Groups (Sample for the Study)

School/Group	Male	Female	Total
SHS A (Lecture-based group)	27	6	33
SHS B (Analogy-based group)	30	12	42
SHS C (Animation-based group)	35	13	48
Total	**85**	**40**	**123**

Data Collection Instrument

One instrument was used for data collection in the study. It was Circulatory System Achievement Test (CAT). The CAT was made up of twenty (20) multiple choice test items, five (5) true or false items and five (5) fill-in the blanks with words or phrases, which was based on the contents of human circulatory system. Though the same instrument (CAT) was used for pre-test, post-test and delayed post-test. The test items were similar and not same in content, and also reshuffled and printed in different coloured papers in each test administration to make them appear different at a glance in order to avoid the students cramming the question items.

Validity, Pilot and Reliability of Instrument

The instrument was subjected to both face and content validity scrutiny by experts in the subject area. After validation exercise, most of the items in the instruments were found to be satisfactory and met the requirement of content validity of the syllabus, as per the agreement of all the experts. Based on the critique and suggestions from the experts, the researcher made amendments such as reframing some of the test items before the final items were used for pilot testing.

Second year General science biology students at a Senior High School in the same study area was purposively and conveniently selected for the pilot testing of the instrument (CAT). This school had similar characteristics as those schools used for this study. The reason for pilot testing of CAT was to establish the validity and reliability of the test items. It was also used to ascertain the discrimination and difficulty indices of the test items.

The reliability coefficient of the instrument was calculated to be 0.84 using Kudder-Richardson formula 20 (KR-20). The instrument was considered to be reliable enough for data collection in this study because it was within the acceptable benchmark of reliable instruments (Leedy & Ormrod, 2005).

Data Collection Procedure

The Researchers sought an approval from the authorities of the selected schools to carry out the study in their schools. The three intact second year biology classes in the three selected schools were first tested through the pre-CAT instrument to know their knowledge entry level of the concept prior to the treatment. Each of the three teaching groups was randomly assigned to one of the three teaching methods using balloting method. Through the balloting, students from SHS A assigned as a control group was subjected to traditional lecture-based teaching method. SHS B assigned as experimental group 1 was subjected to the analogy-based teaching method while SHS C assigned as experimental group 2 was subjected to animation-based instructional teaching method. The students in the groups were exposed to human blood circulatory system using their respective teaching method for a period of three weeks. The post-CAT was administered right after the third week period and this test was to measure the students' knowledge and performance in the concepts. The delayed/post post-CAT was administered three weeks after the posttest and it was to measure the extent to which the respective teaching methods have improved the students' retention.

Data Analysis

Scores from the students in the pre-CAT, post-CAT and delayed post-CAT form the data for the study. Data were analysed using various statistics with the help of statistical package for social sciences (SPSS) version 20 at 0.05% alpha level of significance.

Specifically, to address the research question one and its corresponding null hypothesis, the mean, standard deviation, *eta* squared effect size, analysis of variance (ANOVA), LSD Post Hoc Test, mean and box plots were used to analyse the post-CAT scores.

Also, to address the research question two and its corresponding null hypothesis, the mean, standard deviation, Cohen *d* and *eta* squared effect size, paired samples t-test, analysis of covariance (ANCOVA), LSD Post Hoc Test and box plot were used to analyse the delayed post-CAT scores (retention test scores) of the three teaching groups.

RESULTS AND DISCUSSION

In order to determine whether the students selected from the three schools are equivalent in terms of knowledge in the concepts, their pre-test scores were analysed using both descriptive and inferential statistics (ANOVA). The result of the descriptive statistics is shown in Table 2.

Table 2: Descriptive Statistics of Homogeneity of the Sampled Students from the Three Schools in the Concept of Circulatory System Prior to Treatment

Selected Schools	N	Mean	Std. Deviation
SHS A	33	16.61	4.45
SHS B	42	16.35	4.10
SHS C	48	16.47	4.44
Total	**123**	**16.48**	**4.29 (4.33)**

The data on students' achievement in the concept of blood circulatory system prior to the study, which is indicated in Table 2 reveals that students from SHS A had a mean achievement score of 16.61 with standard deviation of 4.45 while that of SHS B and SHS C had a mean achievement scores of 16.35 and 16.47 with standard deviations of 4.10 and 4.44 respectively. Furthermore, ANOVA analysis is used to determine whether there was any statistically significant difference among these three mean scores of the students from these three schools is presented in the Table 3.

Table 3: ANOVA Analysis of Homogeneity of Sampled Students Performance in the Three Schools on Circulatory System Concept Prior to Treatment

	Sum of Squares	df	Mean Square	*F*	Sig.	*Eta* Squared
Between Groups (Selected Schools)	2.32	2	1.16	.062	.940	.001
Within Groups	2246.19	120	18.72			
Total	**2248.50**	**122**				

Table 3 reveals that there was no statistically significant difference in pre-CAT scores between the sampled students from the three selected schools at $p<.05$ level [$F_{(2,120)} = .062$, $p = .940$]. That is, prior to the study the sampled students from the three schools (SHS A, SHS B and SHS C) were almost at the same entry point in terms of their knowledge on blood circulatory system concept and therefore suitable for the study. Presentation of results and discussion is done in line with the research questions.

Research Question 1

What difference exists in performance among student groups taught with lecture-based, analogy-based and animation-based teaching in human blood circulatory system?

The mean performance scores and standard deviation obtained by students for traditional lecture-based, analogy-based and animation-based methods of the teaching groups are presented in Table 4.

Table 4: Descriptive Statistics of Students Post-test Scores (Performance) after Treatment

Teaching Methods	N	Mean	SD	SE	Min.	Max.
Lecture-based (SHS A)	33	21.76	3.29	.57	17	27
Analogy-based (SHS C)	48	26.65	2.09	.30	22	30
Animation-based (SHS B)	42	25.50	2.46	.38	20	30
Total	**123**	**24.94**	**3.25**	**.29**	**17**	**30**

Table 4 reveals that the post-test mean scores were 21.76, 26.65 and 25.50 while the standard deviations were 3.29, 2.09 and 2.46 for traditional lecture-based, analogy-based and animation-based teaching method respectively. Students from analogy-based teaching had the highest post-test mean score followed by students from animation-based teaching and traditional lecture-based students with least post-test mean score. The descriptive analysis of the post-test score from Table 4 is presented graphically in Figure 2.

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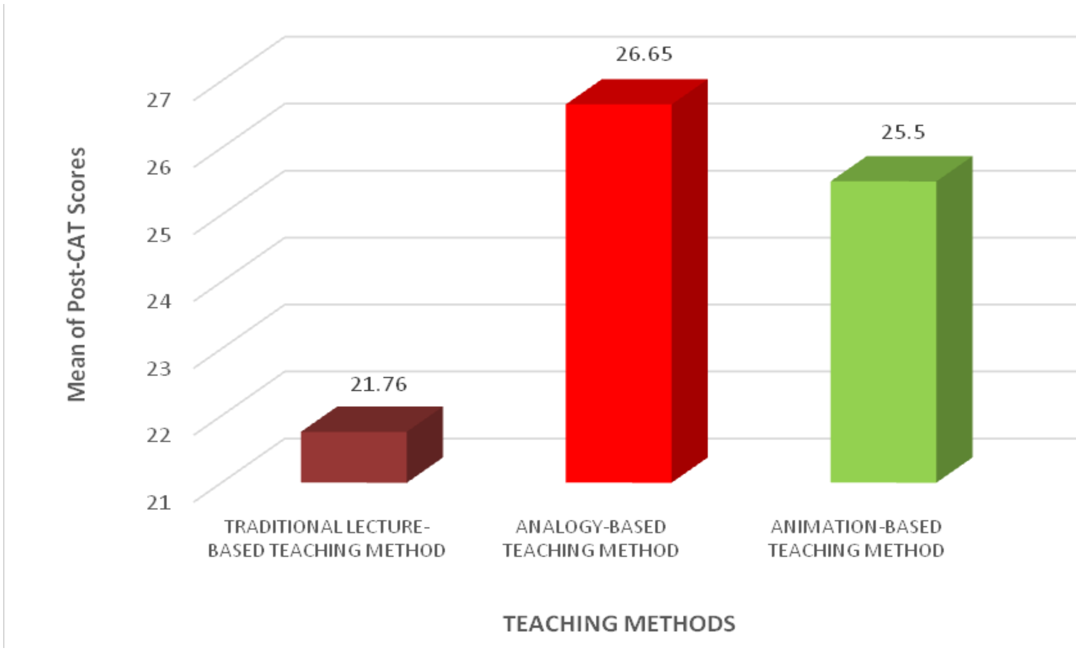

Figure 2: Bar Graph of Students Post-CAT Mean Scores from the Three Teaching Groups

Table 5: One Way ANOVA Statistics of Students' Performance on the Circulatory System Concept at the End of the Teaching Period

	Sum of Squares	df	Mean Square	F	Sig.	*Eta* Squared
Between Groups (Teaching Methods)	487.06	2	243.53	36.55	.000	.22
Within Groups	799.54	120	6.66			
Total	**2248.50**	**122**				

Dependent Variable: Post-CAT Scores

Result of the one way ANOVA statistics in Table 5 shows that significant difference exists among the three teaching group of students at the p<.05 level in the post-CAT [F(2,120) = 36.55, p = .000] with medium effect size of .22 calculated using eta squared. Since significant difference exists among the three teaching groups, multiple comparison analysis was further carried out using least significant difference (LSD) post hoc test to ascertain where the difference exist among the groups. The result of the analysis is presented in Table 6.

Table 6: LSD Post Hoc Test (Multiple Comparison Analysis) of the Students Performance Mean Score

Teaching methods (I)	Teaching methods (J)	Mean Diff. (I - J)	SE	Sig.
Lecture-based Method	Analogy-based Method	-4.89*	.58	.000
	Animation-based Method	-3.74*	.60	.000
Analogy-based Method	Lecture-based Method	4.89*	.58	.000
	Animation-based Method	1.15*	.55	.038
Animation-based Method	Lecture-based Method	3.74*	.60	.000
	Analogy-based Method	-1.15*	.55	.038

Dependent Variable: Delayed post-CAT Scores
* The mean difference is significant at the .05 level

The LSD post-hoc comparisons analysis in Table 6 indicates that post-test mean score for lecture-based teaching group (*M*=21.76, *SD*=3.29) was significantly different (p = <.001) from analogy-based teaching group (*M*=26.65, *SD*=2.09) in favour of analogy-based group. Again, there was a significant difference (p = < .001) between the lecture-based teaching group (*M*=21.76, *SD*=3.29) and animation-based teaching group (*M*=25.50, *SD*=2.46) in favour of animation-based group. The analysis also reveals a statistical significant difference (p = .03 < .05) between the students exposed to blood circulatory system concept through the use of analogy-based teaching method (*M*=26.65, *SD*=2.09) and animation-based teaching method (*M*=25.50, *SD*=2.46) in favour of analogy-based students group.

That is, students who were taught through analogy-based teaching method outperformed their counterparts who were taught with lecture-based method or animation-based method. The higher mean achievement score and low standard deviation in the post-test score showed that most students in the analogy-based teaching group performed impressively better in the blood circulatory system concept after being exposed to the analogy-based teaching method than those who were taught the concept using traditional lecture-based teaching or animation-based teaching method. Furthermore, the illustrations in the box plot (Figure 3) confirm the extent to which the students taught with analogy-based method had improved in terms of performance in blood circulatory system concept compared to their colleagues in the traditional lecture-based and animation-based teaching groups.

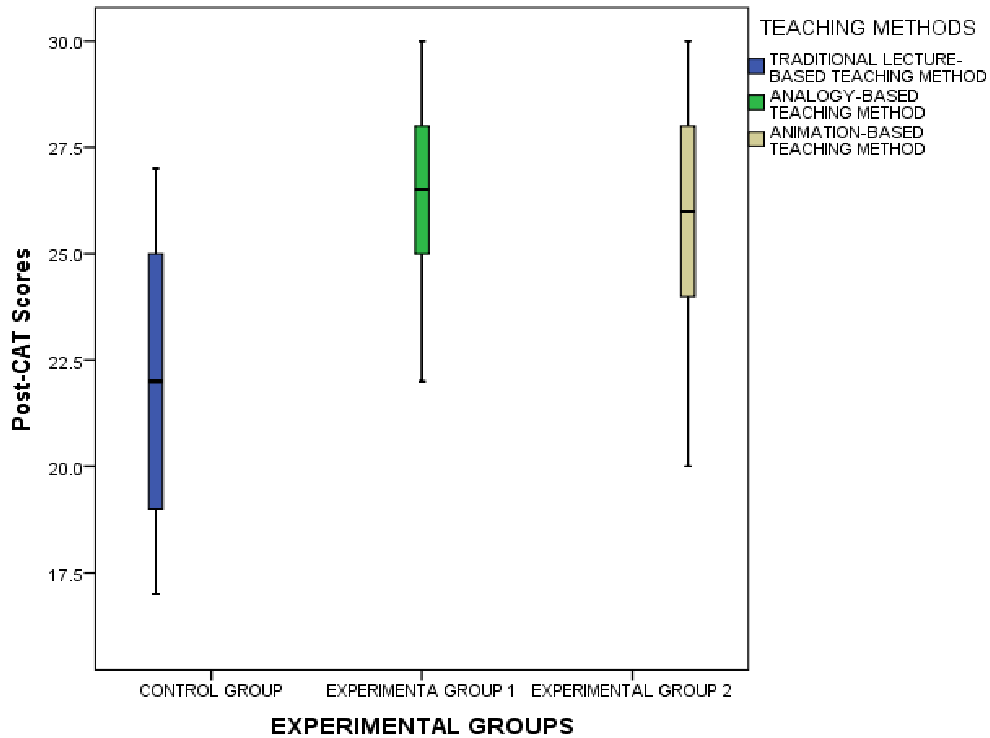

Figure 3: Box Plot Analysis of Students' Performance in Human Circulatory System Concept

It can be observed from Figure 3 that students in the analogy-based teaching group outperformed their counterparts in the other two teaching groups of the concept. For instance, it can be seen from the box plot that the minimum score the students in the analogy-based teaching group obtained in the post-test was 22 which is higher than the minimum scores 16 and 20 obtained by the students in the traditional lecture-based and animation-based teaching groups respectively. This means that when analogy-based instructional approach is effectively used, it could improve students' academic performance more than the use of traditional lecture-based and animation-based teaching methods for teaching blood circulatory system concept.

The reason for the impressive performance of analogy-based students group is not far fetch from the fact that the lesson was based on the use and thinking of related analogies from their surroundings or examples from their previous experience (e.g. *the water-tower analogy of the human circulatory system* used in this study). The effort of the students to think of related analogies from their surroundings or examples from their previous experience seemed to align more logically with constructivism which emphasised the importance of involving students' pre-existing knowledge makes learning more meaningful (Haglund & Jeppsson, 2012). Teaching with analogies allows students to actively participate in the learning process. Analogies can help students relate new information to prior knowledge, to integrate information for one subject area into another. It also relates classroom information to everyday experiences. In this case, students are able to convert abstract knowledge into concrete knowledge and thereby overcome alternative conceptions.

This finding concurs with the findings of Ameyaw and Kyere (2018), Nawaf (2016) and Ayanda, Abimbola and Ahmed (2012). Their study findings indicate that teaching with analogies support meaningful learning and help students to construct complicated and abstract concepts easily and therefore improve their academic performance of such concepts.

Research Question 2

What difference exists in retention rates among student groups taught using lecture-based, analogy-based and animation-based teaching groups in human blood circulatory system?

Paired samples t-test was used to examine the extent of decline in mean scores in each of the three teaching groups from post-CAT to delay post-CAT and the result is presented in Table 7.

Table 7: Mean Decline and Paired Samples *t*-test Results for Post-CAT and Delayed post-CAT Scores in the Three Teaching Groups

Teaching Groups	$\bar{x}_p$	$\bar{x}_D$	Mean Decline ($\bar{x}_p$ - $\bar{x}_D$)	SD	*df*	*t*	*p*-value	Effect Size (Cohen *d*)
Lecture-based (SHS A)	21.76	17.91	3.85	5.32	32	4.15	.000	2.43
Analogy-based (SHS C)	26.65	25.27	1.38	3.71	47	2.57	.013	1.32
Animation-based (SHS B)	25.50	22.57	2.93	4.18	41	4.55	.000	1.94

$\bar{x}_p$ = Mean score of the post-CAT, $\bar{x}_D$= Mean score of the delayed post-CAT

Table 7 presents the extent of decline in students' mean score from the post-test to delayed post-test in each of the teaching groups. It can be seen from Table 7 that there is a statistically significant mean decline between the post-CAT score and delayed post-CAT score across students in all the three teaching groups. However, students' in the analogy-based teaching group had the lowest mean decline score of 1.38 with highest delayed post-test mean score of 25.27 ($\bar{x}_D$= 25.27) compared to that of animation-based teaching group having a mean decline score of 2.93 with a delayed post-test mean score of 22.57 ($\bar{x}_D$= 22.57). The traditional lecture-based teaching group had the highest mean decline score of 3.85 against the delayed post-test mean score of 17.91 ($\bar{x}_D$= 17.91) as seen in Table 8.

However, to examine whether there was any statistically significant difference in the mean decline scores among the three teaching groups, their retention test scores (delayed post-CAT scores) were subjected to one way ANCOVA as presented in Table 8.

Table 8: Summary of Analysis of Covariance (ANCOVA) of Students Retention Ability

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	Partial Eta Squared (η_p^2)
Student Sex (Covariate)	.11	1	.11	.011	.915	.00
Teaching Method	1062.38	2	531.19	53.92	.000	.48
Error	1172.38	119	9.85			
Total	**63808.00**	**123**				

Dependent Variable: Delayed post-CAT scores

It could be deduced from Table 9 that there was a statistically significant difference in the mean retention scores (delayed post-CAT scores) among the students in the three teaching groups with large effect size [$F(2,123) = 53.92$, $p < .001$, $\eta_p^2 = 0.48$]. Multiple comparison test analysis was then carried out to ascertain where the difference exists among the 3 teaching groups using the LSD post hoc test analysis and the result of the analysis is shown in Table 9.

Table 9: LSD Post Hoc Test (Multiple Comparison Analysis) of the Students Retention Ability

TEACHING METHODS (I)	TEACHING METHODS (J)	Mean Diff. (I - J)	SE	Sig.
Lecture-based Method	Analogy-based Method	-7.36*	.71	.000
	Animation-based Method	-4.67*	.73	.000
Analogy-based Method	Lecture-based Method	7.36*	.71	.000
	Animation-based Method	2.70*	.66	.000
Animation-based Method	Lecture-based Method	4.67*	.73	.000
	Analogy-based Method	-2.70*	.66	.000

Dependent Variable: Delayed post-CAT Scores
* The mean difference is significant at the .05 level

The LSD post-hoc comparisons analysis in Table 9 indicates a statistically significant difference (p = <.001) in retention mean scores (delayed post-test mean scores) between students exposed to human circulatory system concept through analogy-based teaching method (*M*=25.27, *SD*=2.62) and lecture-based teaching method (*M*=17.91, *SD*=3.83) in favour of analogy-based students group. The analysis also point out that the delayed post-test mean score for students in lecture-based teaching group (*M*=17.91, *SD*=3.83) was significantly different (p = <.001) from animation-based teaching group (*M*=22.57, *SD*=3.05) in favour of animation-based group. Again, there was a significant difference (p = < .001) in retention mean scores between the students from analogy-based teaching group (*M*=25.27, *SD*=2.62) and animation-based teaching group (*M*=22.57, *SD*=3.05) in favour of analogy-based group.

That is, students who were taught through analogy-based teaching method outperformed their counterparts who were taught with lecture-based method or animation-based method in terms of retention of the concept. The higher mean achievement score and low standard deviation in the post-test score showed that most students in the analogy-based teaching group retained more of the learnt concept than those who were taught the concept with traditional lecture-based teaching or animation-based teaching method.

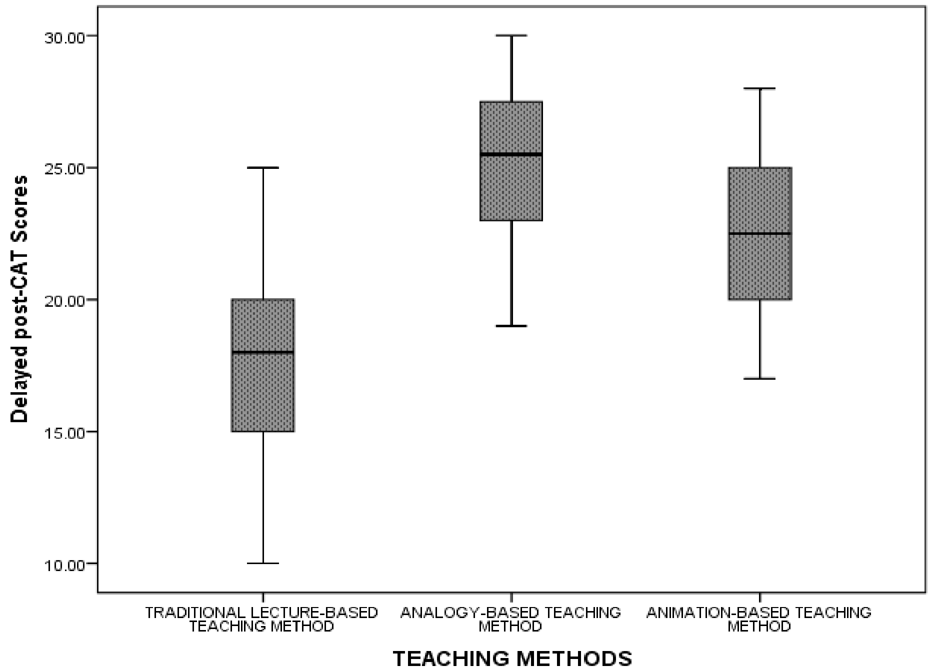

Figure 4: Box Plot Analysis of Students Retention Ability in Human Circulatory System

From Figure 4, students from the analogy-based teaching group did better compared to those from the traditional lecture-based teaching group or animation-based teaching group in terms of the retention of the human blood circulatory system concept. For instance, as observed from the box plot the minimum score students in the analogy-based group obtained from the retention test (delayed post-CAT) was 19 which is higher than the minimum scores of 17 and 10 for students in the animation-based teaching group and traditional lecture-based group respectively. In the same way, the maximum score students in the analogy-based group obtained from the retention test was 30, which is higher than the maximum score of 23 for animation-based teaching group and 18 for traditional lecture-based group. It can also be deduced from the box plot that the median score students in the analogy-based instructional group obtained from the retention test was 25 which is higher than the median score obtained by the animation-based teaching group or traditional lecture-based group, which were 23 and 18 respectively.

It is therefore plausible to conclude that the retention ability of the concept of students who were taught with analogy-based teaching method significantly improved more than their counterparts who were exposed to the concept either through animation-based teaching method or traditional lecture-based teaching method. This might be due to the process of establishing associations with elements, events and processes in the environment which helped students in the analogy-based teaching group to expand their mental networks and recall the information much longer than the animation-based teaching and traditional lecture-based teaching groups. This finding is in line with the findings of Mangal (2011) and Owolabi (2007). Their findings proved that teaching with analogy can help improve students' retention of the learned concept which is through association of ideas, connection, and systematic thinking in the task of recall.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The findings of the study have shown that all the three teaching methods have the potential of improving students' academic performance of human blood circulatory system concept. But out of the three, students exposed to analogy-based teaching method exhibited higher level of performance and retention of the human blood circulatory system concept followed by those exposed to the concept through animation-based teaching method with traditional lecture-based teaching method been the least effective teaching method. The reason is not far fetch from the fact that analogy-based instructional approach allowed the students to relate the human blood circulatory system concept DNA concepts to their everyday experiences such as the operation of a city water supply and therefore were able to convert the abstract nature of the concepts into concrete knowledge, though this method has the potential of causing student misconception if the analogy is not enriched. Based on this finding, it is concluded that analogy-based teaching method was more effective and has the higher potential of improving students' academic performance in human blood circulatory system concept. It is therefore expected that the findings of the study can serve as a guide for teachers and students when constructing analogies to help explain abstract and complex concepts in biology especially the human blood circulatory system concept.

Recommendations

The findings of the study revealed that students who were exposed to analogy-based teaching method exhibited high level of performance [$F(2,120) = 36.55$, $p = .000$] and retention [$F(2,123) = 53.92$, $p < .001$, $\eta_p^2 = 0.48$] of human blood circulatory system than those exposed to the concept through traditional lecture-based teaching method or animation-based teaching method.

It is therefore recommended that science teachers should embrace the use of the analogy-based instructional approach in the teaching and learning of human blood circulatory system. Again, teachers should select analogies that are familiar to students to eliminate misconceptions, and avoid time wastage. Teachers should also encourage and guide students to make or construct their own analogies because such analogies are more effective. Biology textbook authors should be encouraged to include enriched analogies in their texts for easy access for students and teachers. Using enriched analogies means the author should indicate the limitations of the analogies (where the analogies break).

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