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The Efficacy of Some Teaching and Learning Instructions That Enhance Students' Performance in Excretion

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Abstract

The primary focus of the study was to determine the efficacy of some instructional adjuvants (concept mapping, co-operative learning, and lecture method) that enhance students' performance in the teaching and learning of excretion. The quasi experimental design of non- randomized pre-test-post-test control group was employed. Purposive sampling technique was used to select three intact biology classes of Aburaman SHS2 students with total sample size of 108. The two main instruments used for data collection were General Knowledge in Biology Performance Test (GKBPT) and Students' Performance Test in Excretion (SPTE) with K-R 20 reliability coefficient of 0.812 and 0.866 respectively. Point Biserial Correlation, Wilcoxon Signed Rank test, effect size, chi-square and Kruskal-Wallis H test were employed to analyse the quantitative data collected through the students' achievement score. The effect sizes of the students' performance both concept mapping and co-operative learning groups were higher than students taught with lecture method. Again, the use of co-operative learning as an instructional approach made the students' performance homogenously in the post-test than the other two instructional approaches. The study again indicated that there was no statistical significant relationship between the instructional approaches the students received and their correct conception of the concept of excretion.

Keywords: Co-operative learning; Concept mapping; Lecture method; Pre-test; Post-test

Introduction

Okwo & Tartiyus [1] posited that Biology is a natural science subject comprising content from microscopic organisms to the biosphere in general, encompassing the earth's surface and all living things. Considering its fundamental characteristics and importance, Biology is today a standard subject of instruction at all levels of our educational systems, from pre-primary to tertiary. Essentially it could be considered the only core science subject at Senior Secondary School Certificate Examination (SSSCE), whose study is very relevant to man's successful living (Akindele, 2009). Biology occupies a unique position in the school curriculum, and is central to many science related disciplines such as Medicine, pharmacy, agriculture, nursing and biochemistry. The knowledge of Biology, chemistry and physics which have been crystallised into concepts, empirical laws and theories form the basis of our material comfort. The knowledge of Biology contributes to scientific literacy so that people can understand the world around them and enable them to make informed choices about their health care, their environment and the society in which they live [2]. As we entered the 21st century and expected better health for all; abundant food for all; better knowledge of man, animals and plants; and less polluted environments with sulphur (IV) oxide and radio-active substances, there is the need to effectively teach and learn Biology to meet these challenges.

The sensitive position Biology plays in medical sciences, environmental sciences and other related disciplines has informed several efforts geared toward studying biology at a secondary level of education in many parts of the world including Ghana. Hence, it is one of the science subjects one must pass so as to qualify to pursue some science courses at the tertiary level of education.

For these reasons, the biology Teaching Syllabus [3] aims at assisting the learner to appreciate the diversity of living things; understand the structure and functions of living things; develop scientific approach to solving personal and societal (environmental, economic and health) problems, develop practical skills required to work with scientific equipment, biological materials and living things; collect, analyse and interpret biological data; and also present data graphically. It also focuses on making biology students aware of the existence of interrelationships between biology and other scientific disciplines; appreciate and understand the interrelationships between organisms and themselves and with the environment, and sustain their interest in studying biology.

Despite the importance of the knowledge of biology for socio-economic development of a country, it has been reported that performance in biology at SHS level has been poor in most parts of the Sub-Saharan Africa and Ghana is no exception [4,5]. Ahmed reported that biology is popular among Nigerian students, yet their performance in it at Secondary School level is low. The situation is not different in Kenya. For instance, the Ministry of Education of Kenya in 2005 indicated that there is a decline in the performance of students in biology.

In Ghana, [4] reported in their study titled "an investigation into weaknesses exhibited by Senior High School biology Students' in graph work in the Cape Coast Metropolis of Ghana" that with the passing of years, many students who sit the SSSCE in the sciences, specifically, biology, do not perform as expected. They further lamented that this has been a constant source of worry to parents, teachers, educationists and those who have the advancement of science education in Ghana at heart. Again, the performance of students in biology has not seen any significant difference over the years as evidenced by the general comments in the West African Examinations Council (WAEC) [4,6-9].

The students' inability to deeply conceptualise the individual topics treated in biology could account for their woeful performance in the biology papers in general. For example, studies consistently showed that students have problems in understanding key topics of biology such as internal organs, organ systems and processes of their own bodies [10-12]. Toyoma [12] evaluated young children's awareness of biological transformations associated with eating and breathing and showed that young children seldom refer to biological transformation. Results from an international study [10] indicated that about 15 year-old students´ (from 11 different countries) understanding of different organ systems showed that the generally best known organs belong to the digestive system, the gaseous exchange system and the skeletal system. It was evidenced in the study conducted by [10] that students had better knowledge of their internal organs but most of them had little understanding of their organ system. Tunnicliffe [11] reiterated that students had greater difficulties in understanding the excretory systems than the digestive.

The students' difficulties in understanding excretory systems are mainly caused by ineffective learning or poor teaching in the classroom [13]. Lawson furthered that when appropriate teaching and learning approaches are not employed in the classroom, students turn to develop certain misconceptions about the topic learned, particularly those that are concerned with more complex or abstract phenomena such as cell division, ultrafiltration in nephrons and the mechanism of circulation, children are less likely to come into immediate and direct contact with them in daily life, and so have little chance to develop their own 'naive' explanations [14-17].

Muraya & Kimamo [18] emphasised that teacher-centred teaching approach, inadequate mastery of subject matter by the teachers and inadequate teaching and learning resources are among other contributing factors that impede students' conception and performance in certain topics in biology. They emphasised that the teaching approach employed by a teacher is one of the most important explanations of poor performance in science subjects. One teaching approach which has been identified to be dominant in Secondary School level is lecture method [19]. It is teacher-centred teaching approach where a teacher presents information to students in a lecture and students complete assignments out of class and later take an examination to demonstrate their degree of understanding and retention of the subject matter. The lecture method which is predominant in our classrooms does not stimulate students' thinking [20,21].

Brown, Oke & Brown [22] opined that teaching and learning is an attempt to help someone acquire or change some knowledge, skill or attitude. Ayot & Patel [23] further argued that teaching and learning is a process where one person, the teacher intentionally passes information to another person, the learner. Hence, the goal of teaching is to bring about desirable learning in students. In this process, the learner is expected to receive information, understand it and use it later when the need arises. For effective teaching and learning to occur, the teacher must use an effective approach of conveying the information to the learner [24]. He further noted that the way a teacher teaches is important in that with the right methods and techniques, students can grasp concepts and ideas while poor methods and techniques frustrate students and minimize their chances of success.

The instructional strategies that have been identified to aid students' conception and performance are concept mapping [25] and co-operative learning [25-27] which is practically non-existent in the situation where the research was conducted.

Statement of the problem

Science contributes immensely towards the socio-economic development of a country. For this reason, the Government of Ghana is committed to improving the quality of science education at all levels but in particular at the basic and the SHS levels [28]. However, performance in biology at Senior High School level in Ghana remains poor over the years [29]. Biology Chief Examiners' reports noted that over the past decades students obtained worse grades in biology than in other pure science subjects. For example, Programme Reform and Alignment for increasing Competencies of Teachers and for Improving Comprehension and Application in Learning Science and Mathematics (PRACTICAL) project plan, showed that in 1999, 2000, 2001, 2002, 2003, 2004 and 2005 students who had grades A to D were 31.7%, 19.2%, 27.6%, 39.0%, 38.7% 39.4% and 40.9% respectively. This indicates that over a period of seven consecutive years less than 50% of candidates had passing

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grades in biology that could qualify them for further studies [4]. The situation is not different from Aburaman Senior High School in the Abura-Asebu-Kwamankese District in the Central region of Ghana.

It is in the light of the above that, this research tends to compare the effectiveness of concept mapping and co-operative learning instructional approaches in relation to lecture method on students' performance in human excretion in the Ghanaian context. The researchers also explored the extent to which students' misconception in human excretion could be rectified by using the concept mapping and co-operative learning as instructional strategies.

Research questions

The following research question guided the study:

Is there any relationship among the students in concept mapping group, co-operative learning group and lecture method group and their conceptions of excretion?

Methodology

This study was meant to determine the effect of concept mapping and co-operative learning approach on performance of Senior High School students in excretion. Therefore, quasi-experimental research design involving non-equivalent pre-test and post-test control group was considered the most appropriate.

According to [30], non-equivalent pre-test and post-test control group design model is a popular approach to quasi-experiments. Gall, Gall, & Borg [31] supported that a quasi-experimental pre-test and post-test control group research design is the most powerful research method for establishing cause and effect relationships between two or more variables. Ofori & Dampson [32] confirmed that this method has the "goal of providing evidence about causal relationship" (p. 150). That is, it tries to find out what leads to what. Another reason for the use of this method is that the participants were not randomly selected and assigned to the groups [30,33]. The use of the intact classes was preferred because randomisation was impractical and unethical since all the lessons were conducted during the school instructional time. Wambugu & Changeiywo [34,35] similarly confirmed that quasi-experimental design has been used successfully in research studies to determine the effect of teaching approaches on student performance in countries like Kenya.

Validity

In this study, face and content validity were used to ascertain the validity of the instrument. Face and content validity are qualitative measures of validity and are often employed in educational research because they are the easiest to ascertain.

Further, item analysis was performed to determine whether an item functions as intended. The item analysis provided information whether the item was of the appropriate level of difficulty or whether it distinguished between high achievers and low achievers or whether the options were working.

Face validity: Burton & Mazerolle [36] defined face validity as the evaluation of an instrument's appearance by a group of experts and/or potential participants. It establishes an instrument's ease of use, clarity, and readability. The face validity points out that the instrument is pleasing to the eye and applicable for intended purpose (Ary, Jacobs & Razavieh cited in Alhassan, 2011). That is the face validity indicates the extent to which the instrument appears to measure what it is meant to measure. In this study the two instruments (teacher-made achievement tests) were given to experts in science education particularly the principal supervisor and the co-supervisor of this thesis to read for necessary corrections and suggestions.

Content validity: Content validity refers to the appropriateness of the content of an instrument [37]. That is, content validity determines whether the questions accurately assess what one wants to know. This is particularly important with achievement tests. It involves taking representative questions from each of the sections of the unit and evaluating them against the desired outcomes. To ensure the content validity in this study, the test was constructed based on the instructional objectives of the lessons taught and the specific objectives in SHS biology syllabus and past questions on excretion from the WASSCE biology papers 1 and 2.

Also, the content of the instruments were assessed by the supervisors of this thesis and were found to be satisfactory. This method of validation of the instrument is supported by [38]. He explained that validity of the instrument refers to intended curriculum level and the validity is usually measured using what is called an expert analysis.

Discrimination Index: The discrimination index was calculated for each test item of the GKBPT and SPTE. The discrimination index is the difference between the percentage of students in upper and lower groups who got the items correct. Generally, students who did well on the test should select the correct answer to any given item on the test. Thus, discrimination index distinguishes for each item between the performance of students who did well on the test and students who did poorly.

To calculate the discrimination index, first the marked papers were arranged from highest score to the lowest score. The papers (N = 60) were grouped into three: upper, middle and lower groups using top 27% (16 students) and the bottom 27% (16 students).

The formula used to calculate the discrimination index is

$$D = \frac{RU - RL}{\frac{1}{2}N}$$

Where D = discrimination index, RU = number among the upper 27% of respondents who scored the item correct, RL = number among the lower 27% of respondents who scored the item correct and N= total number of respondents.

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For examination with a normal distribution, discrimination index of 0.3 and above is good; 0.6 and above is very good. Values close to zero mean that most students performed the same on an item. The index should never be negative [39]. The indiscrimination indices for all the items in the GKBPT were found to be within the acceptable range. However, items Q19, Q22, Q26, and Q27 of the SPTE had low discrimination indices and were carefully examined for possible presence of ambiguity and clues.

Difficulty index: The difficulty index for each item of the GKBPT and SPTE (Appendix C was calculated. The difficulty index is the percentage of the total number of students who got the item correct. Difficulty index can also be interpreted as how easy or how difficult an item is. This was calculated using the following formula

$$DI = \frac{R}{T}$$

Where: D1 = difficulty index, R = number of correct responses, T = total number of students.

Santos [40] suggested a benchmark for interpreting the difficulty index. He suggested that items with difficulty index of 0.00 to 0.25 means the item is difficult and needs to be revised or discarded, 0.26 to 0.75 means the item is appropriate and needs to be retained and 0.76 to 1.0 means the item is too easy and the item needs to be revised or discarded.

From the calculation, items 14, 17, and 30 of SPTE were above easy levels of difficulty. These items were revised and maintained. In all, the results from the difficulty index helped to carefully examine the options for each item and the necessary corrections were then made.

Reliability: The Kuder-Richardson 20 formula (K-R 20) was used to determine the reliability coefficient of achievement test items. The reason for choosing K-R 20 test statistics is it measures the internal consistency of items with dichotomous choices. It is analogous to Cronbach's alpha, except that the Cronbach's alpha is to use items that are non-dichotomous (continuous) [41,42]. Table 1 provides the reliability coefficients of the achievement tests.

From Table 1, the K-R 20 reliability coefficient of the achievement test items for GKBPT and SPTE were found to be 0.812 and 0.866 respectively. The reliability coefficient of 0.866 means that 86.6% of variability in scores is due to true score differences among examinees, while the remaining 14.4% (1.00 - 0.866) is due to measurement error. Therefore, the reliability coefficients of 0.182 and 0.866 obtained in this study confirmed that the achievement tests used in the study were within the acceptable benchmark of instruments as being reliable [27,43,44].

Table 1: The Reliability Coefficient of the Achievement Tests.

Test	Number of students	Number of items	K-R 20
GKBPT	60	30	0.812
SPTE	60	30	0.866

Instruments

The main instruments used in the study were the two made achievement tests: General Knowledge in Biology Performance Test (GKBPT) and Students' Performance Test in Excretion (SPTE). Both tests were developed by the researchers.

The GKBPT comprised 20 multiple choice test items, 5 true or false test items and 5 fill-ins the blanks. The questions were constructed from the treated topics drawn from the elective biology syllabus. The GKBPT was used for the pre-test. The purpose of the pre-test was meant to determine students' level of understanding in some of the biology topics treated. It was also to help identify which classes could be best match, so as to ensure the equivalence of the selected groups and consequently the credibility of the study findings [45].

The Students' Performance Test in Excretion (SPTE) also consisted of 20 multiple choice test items, 5 true or false test items and 5 fill-ins the blanks; but the questions were constructed based on the lessons taught and the learning objectives of the SHS biology curriculum. The SPTE was used as a post-test to assess students' performance and conception in excretion after the instructional period.

The teacher made-achievement test (GKBPT and SPTE) was preferred in this study to other types of tests for the following reasons. It reflects instruction and curriculum; it is sensitive to student's ability and needs; it provides immediate feedback about student progress; and finally, it can be made to reflect small changes in knowledge [46].

On the other hand, teacher-made achievement test has been criticised that it may not reflect content standards; it has little variety in types of assessment used; it is informal or unstandardised; and it has concerns about validity and reliability. In this study, the following measures were taken to address these concerns. The principles of test construction provided by [46,47] were followed strictly to construct the test items; table of specification was prepared and used for the construction of the test items; content and face validity were ascertained by supervisors of this study; and finally, the instrument was pilot tested to ascertain its validity and reliability.

Aside the teacher-made achievement test which was the main instrument for the study, researcher's log book, lesson plan and students' worksheet were used to complement the

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data collected. For instance, the researchers' log book was used to maintain a record of activities and events occurring during the classroom implementation of lessons. Also, the lesson plan for each instructional group was used to guide classroom instructional activities. The lesson plan spelt out the lesson objectives, duration of the lesson, contents to be learnt, teacher/learner activities, mode of assessment and remarks. Finally, the students' worksheet entailed the guided activities which the students followed through to enhance conceptual development and understanding of the topic (excretion). Copies of the students' worksheet were provided for each instructional group.

Data analysis

Students' written responses to questions on excretion were analysed qualitatively. Again, since the sample was selected purposively, Wilcoxon Signed Rank Test which is non-parametric test for paired sample t-test and effect size statistics were used. Box plot was also used to give pictorial representation of the performance of the students in the achievement test. The Wilcoxon Signed Rank Test statistic was also used to find out whether the performance of the students within each group improved or not while the effect size was used to determine the magnitude of improvement in each group. The choice of the Wilcoxon Signed Rank Test statistic was essential because two observations (i. e. pre-test scores and post-test) were made on each student in the concept mapping and co-operative learning groups.

Again, the students' written responses of homework assignments and class exercises were analysed qualitatively to bring out the extent to which the use of each instructional approach (concept mapping, co-operative instructional and lecture method group) helped improve students' conception of human excretion. Also, the chi-square statistic was used to establish whether there was a significant relationship among the students in concept mapping group, co-operative learning group and lecture method group and their conceptions of excretion.

The Kruskal-Wallis H test statistic was used to test the hypothesis. It is considered the nonparametric alternative to the one-way ANOVA. The Kruskal-Wallis H test is a rank-based nonparametric test used to determine if there are statistically significant differences between two or more groups of an independent variable on a continuous or ordinal dependent variable. In this study the Kruskal-Wallis H test was employed for the following reasons:

a) The subjects were not randomly selected

b) The normality assumption was not met

c) The independent variable was the instructional approach categorised-lecture method group, concept mapping group and co-operative learning group

d) The dependent variable which was students' performance in the excretion achievement test was a continuous data

e) There was an independent observations (i.e. there was no relationship between the observations in each group or between the groups themselves. There were different participants in each group with no participant being in more than one group)

Finally, Cohen d statistic was used to determine the effect size. Since the difference in the students' performance of excretion by the three groups could occur by chance, the effect statistic provides an indication of the magnitude of the difference within groups and among the three groups The bench mark for interpreting Cohen d values are 0.20= small effect, 0.50 = moderate effect, 0.80 = large effect and 1.30 = very large (Ellis, 2009). Therefore, the Cohen d value determined in this study was compared with these standard values and conclusion drawn thereafter.

Result

All statistical works used for making analysis, testing hypotheses, and interpreting results as evidenced-based answers to the research questions have been presented below.

Is there any relationship among the students' performance in the groups: concept mapping, co-operative learning, and lecture method and their conceptions of excretion?

After the students had received instructions in their respective groups, the researcher was interested to know whether they had developed correct conception of excretion or otherwise. This investigation was premised on studies that indicated that students harbour many misconceptions relating to basic biological concepts after teaching [47,48]. In this study, the relationship of students' conception of excretion in terms of particular instructional approach they received was determined through the written responses the students gave to the questions on excretion. The students' responses to each item consisted of two parts. The first part required the students to highlight the part(s) of the statement that is/are incorrect by underlining the relevant words or phrases. The second part was a justification of the students' choice. An item was considered to be answered correctly only when the incorrect part is highlighted, together with a proper explanation. Thus a wrong response for an item would suggest that the student held an erroneous or inaccurate idea of the concept concerned. The elaboration provided by the students might also reveal the students' thinking processes and the causes of misconception. Most questions asked tested students' knowledge/comprehension and application/analysis skill levels. The analysis of the students' response to the items on excretion is illustrated in the following paragraphs.

Definition of deamination: The statement was "Deamination is the removal of the amino group from urea to make ammonia". This question was purposively asked to test whether the

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students could recall the definition of the term deamination. The statement is incorrect because of the word urea. The students needed to recall that deamination is the removal of the amino group from amino acid to make ammonia and therefore they were required to underline the word urea and replace it with amino acid. In the human body, surplus amino acids are normally deaminated to form ammonia and a-keto carboxylic acids; the ammonia then combines with carbon dioxide to form urea through the ornithine cycle while the carboxylic acids are metabolised as carbohydrates or lipids. It was found that most students in the three instructional groups gave satisfactory response. The frequency count of the students' responses on the definition of deamination according to their instructional groups is shown in (Table 2).

Table 2: Frequency Count of Students' Responses on the Definition of Deamination.

Instructional Group	Number of student who provided		Total
	Correct response (%)	Wrong response (%)	
Concept mapping group (N = 35)	27 (77.1))	8 (22.9)	35 (100.0)
Co-operative learning group (N = 41)	30(73.2)	11(26.8)	41 (100.0)
Lecture method group (N = 32)	19(59.4)	13 (40.6)	32(100.0)
Total	76(70.4)	32 (29.6)	108 (100.0)

Chi-square ( ) = 33.273, df = 2, phi = .555, p- value = .001

The study showed that most of the students across the three instructional groups were able to define the term deamination satisfactorily. This was derived from the fact that 77.1% of students taught with concept mapping, 73.2% of students taught with co-operative learning and 59.4% of students in the lecture method group provided pleasingly definition of deamination. It can be seen from this results that, a greater percentage of students in the concept mapping group were able to define deamination followed by co-operative learning group and then lecture method group.

It was also found that there was statistically significant relationship between the instructional approach the students received and their ability to define the term deamination (Chi-square, (2) = 33.273, p-value = .001). The results therefore showed that the differences in the students' conception of the definition of deamination were related to the instructional approaches used. Thus, majority of the students who received instruction in concept mapping group and co-operative learning group held correct conception regarding the term deamination.

The excretory organ of insects: This question consists of the statement that "The intestine and rectum are the main excretory organs in insects". There was fallacy embedded in the statement and therefore the statement is incorrect. This question sorted to test students' knowledge and comprehension of the function of malpighian tubules in insect. Here, the students were expected to conceptualise that malpighian tubules are found in the posterior regions of insects, where they work with glands in the rectum to excrete waste and maintain osmotic balance (Figure 1). Therefore the intestine and the rectum are not the main excretory organs of insects, it is rather malpighian tubules.

The analysis of the students' response to this question indicated that while a greater number of students across the three instructional groups impressively did well, others erroneously underlined either intestine or rectum or both and replaced it with words such as lungs, amino acid and skin. The distribution of students' responses according to their instructional groups is illustrated in (Table 3).

The result in (Table 3) indicated that 79 [concept mapping group (28), co-operative learning group (32) and lecture method group (19)] out of 108 of the subjects had correct conception that malpighian tubules are the main excretory organ in insects. However, 29 [concept mapping group (7), co-operative learning group (9) and lecture method group (13)] of 108 of the subjects could not conceptualise that the malpighian tubules are the main excretory organ in insects. It was observed that most of the students who could not grasp this concept came from the lecture method group followed by co-operative learning group and then concept mapping group. Also, the result indicated that there was no statistically significant relationship between the instructional approach the students received and their correct conception of the excretory organ of insects (Chi-square ( ) = 4.248, df = 2, p-value = .109). Thus, irrespective of the instructional approach the students had, they held similar conception of excretory organ of insects.

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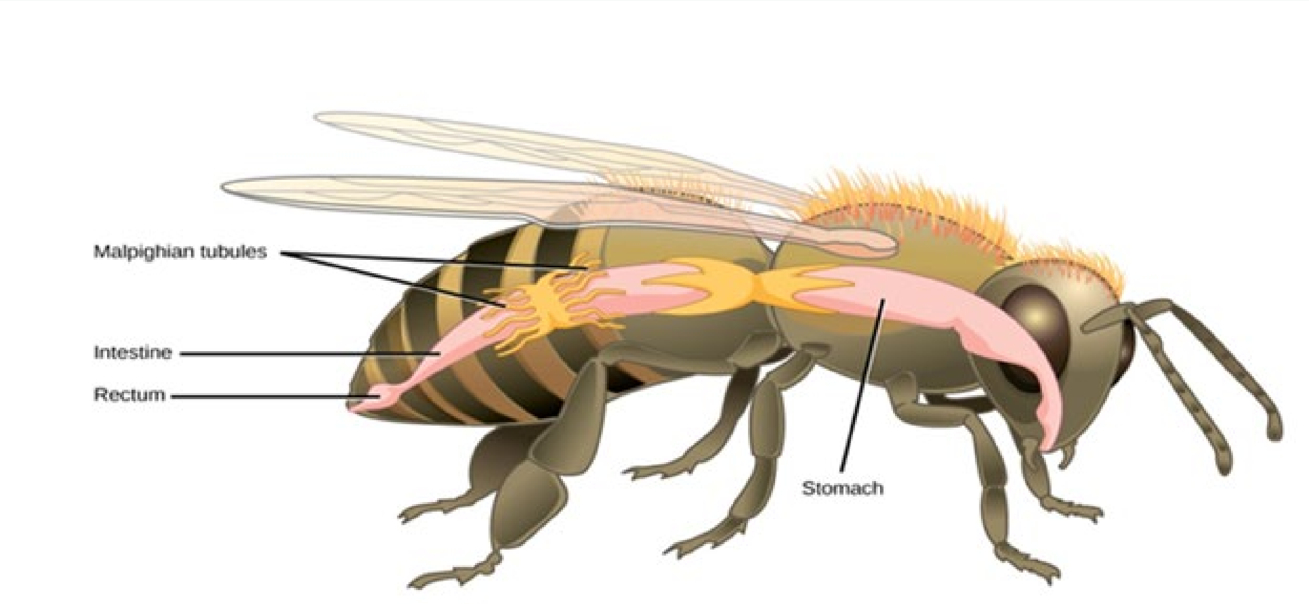

Figure 1: The Excretory Organ of an Insect; Source: Boundless Biology (2016)

Table 3: Frequency Count of Students' Responses on the Excretory Organ of an Insect.

Instructional Group	No. of students who provided		Total
	Correct Response (%)	Wrong Response (%)	
Concept mapping group (N = 35)	28 (80.0)	7 (20.0)	35 (100.0)
Co-operative learning group (N = 41)	32 (78.0)	9 (22.0)	41 (100.0)
Lecture method group (N = 32)	19 (59.4)	13 (40.6)	32(100.0)
Total	79 (73.1)	29 (26.9)	108 (100.0)

Chi-square ( ) = 4.248, df = 2, phi = .202, p-value = .109

Osmoregulation and excretion: Because osmoregulation is a conceptual process that involves an understanding of biochemistry, form and function, and environmental constraints, students were asked free-response question to ascertain their understanding on osmoregulation and excretion. The question asked read "A marine sea star was mistakenly placed in freshwater instead of sea water and it died shortly afterward. What is the most likely explanation for its death?" This item was a high order level question which required the students to apply and analyse the concept they had learned on osmoregulation and excretion to explain why the marine sea star died shortly after it had been placed in freshwater. Here, the students needed to conceptualise that water is more likely to move into the cell through osmosis in a cell membrane or other membrane-bound object which has a higher concentration of solutes than its surroundings (i.e. hyperosmotic). Osmoregulation on the other hand is the active regulation of the osmotic pressure of an organism's body fluids to maintain the homeostasis of the organism's water content; that is, it maintains the fluid balance and the concentration of electrolytes (salts in solution) to keep the fluids from becoming too diluted or too concentrated. Therefore, having grasped these concepts the student was expected to explain that "The sea star died because it is hyperosmotic to the freshwater, and it could not osmoregulate". The tabulation of students' responses into correct explanation, wrong explanation and no attempt is shown in (Table 4).

The analysis of the students' responses from the various instructional groups indicated that the students in the concept mapping group (51.4%) and co-operative learning (56.1) group on average provided satisfactory explanation while the less than half of the students in the lecture method group (37.5%) provided

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satisfactory explanation to the problem. Some students (names attached to their statements) across the various instructional groups erroneously indicated that

1) The sea star died because the temperature in the fresh water was high than that of the sea (Aboagye, pseudonym)

2) The sea star was stressed and needed more time to acclimate to new conditions (Kwarteng)

3) The cells of the sea star dehydrated and lost the ability to metabolise (Pokuwaa)

Also, from the results indicated in Table, there was no statistically significant relationship between the instructional approach the students received and their correct explanations of why the marine sea star died shortly after it had been placed in freshwater (Chi-square ( ) = 5.218, df = 4, phi = .220, p- value = .266). That is, the students' ability to apply the concept of osmoregulation and excretion to answer real life problem is independent of the type of instructional approach they were taken through.

Table 4: Frequency count of Students' Responses on the Osmoregulation and Excretion.

Instructional group	No. of students who provided			Total
	Correct explanation (%)	Wrong explanation (%)	No attempt (%)	
Concept mapping group (N = 35)	18 (51.4)	10 (28.6)	7 (20.0)	35 (100.0)
Co-operative learning group (N = 41)	23 (56.1)	8(19.5)	10 (24.4)	41 (100.0)
Lecture method group (N = 32)	12 (37.5)	14 (43.8)	6 (18.8)	32(100.0)
Total	53 (49.1)	32 (29.6)	23 (21.3)	108 (100.0)

Chi-square ( ) = 5.218, df = 4, phi = .220, p- value = .266

Discussion

The effectiveness of concept mapping, co-operative learning and lecture method on students' performance and correct conception of excretion

The result of this study showed that the performance of the students who received instruction in concept mapping approach, co-operative learning approach and lecture method approach improved significantly. However, the students in the concept mapping group and co-operative learning group had large effect size while their counterparts in the lecture method group had moderate effect size. While the unique and significant effects of concept mapping and co-operative learning on students' achievement over and above lecture method is applauded, there are several specific observations that were made about the findings in relation to the various instructional methods.

First, the analysis indicated that all the three instructional methods had significant effects on students' achievement in excretion. Since the post-test scores of all the students in all the groups were significantly greater than their pre-test scores, it therefore follows that the post achievement test scores was earned not by chance but as a result of treatment with the prescribed instructional methods. This implies that all the methods compared have the potential to cause learning to take place but at varying degrees which is the bases for this study. This study was to establish a cause and effect relationship as found, agrees with the principle of experimental research as recommended by [25,27,44]. They all established that in experimental research, a treatment must be confirmed to be responsible for any difference noticed.

Secondly, it was evidenced in this study that the use of co-operative learning as an instructional approach made students perform homogenously as compared to the other two instructional approaches. The students in the co-operative learning group recorded the least standard deviation (2.24) in the post-test followed by lecture method group (3.39) and then concept mapping group (3.50). That is, the variability among students is reduced when students are engaged in co-operative learning while concept mapping and lecture method instructional approaches increase students' variability. The variations in achievement scores among the groups may be due to the diversity in the teaching strategies adopted in each of the groups and their comprehension of the methods of instruction. This might have translated into influencing their scores in the achievement test. Furthermore, the dissimilarity in the levels of achievement among students taught with the different strategies was a direct reflection of the theoretical framework under which the methods evolved. For instance, the instructional methods framed under the constructivist teaching and learning produced students with higher scores, while the method hinged under behavourist teaching and learning produced students who scored lower marks because of the varying level of students' activities in the lessons.

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Further, the Kruskal-Wallis H test conducted in this study showed that there was a statistically significant difference among the three instructional groups' performance in excretion achievement test. The post hoc analysis proved that the performance of co-operative learning group was significantly better than their counterparts in the lecture method group. Also, the concept mapping group significantly outperformed the lecture method group. On the other hand, there was no significant difference between the performance of the co-operative learning group and the concept mapping group in the post-test. The post hoc analysis which indicated that all the students taught with concept mapping and co-operative learning strategies outscored those taught with lecture method suggests that the students in these groups may have been more active in the learning process than those in the lecture group and thus contributing to their higher achievement scores. This is hinged on the fact that students learn better by doing. The low achievement scores as found among the students taught with lecture method may not be unconnected with the transmission approach involved, where the teachers pass over their knowledge to their students. This finding is consistent with the results of the study conducted by [50]. In his study, he compared the achievement of students taught with concept mapping, co-operative learning, 5E learning cycle and lecture methods with the intention of identifying which one among them could be most suitable for teaching biology. Among the major findings he identified was that the students who were taught with concept mapping, co-operative learning and 5E learning cycle outperformed their counterparts taught with lecture method. Similar results were also found in the studies conducted by [24,51-54].

Finally, it was found in this study that majority of the students in the concept mapping group and co-operative learning group had correct conception of excretion as compared with students in the lecture method group. For instance, it was found that 77.1% of students taught with concept mapping, 73.2% of students taught with co-operative learning and 59.4% of students in the lecture method group provided appropriate definition of deamination. It can be seen from this result that most students in the concept mapping group were able to give the definition of deamination as compared with the other instructional groups. The Chi-square analysis performed proved that there was statistically significant relationship between the instructional approach the students received and their ability to define the term deamination. Again, it was evidenced in this study that while more than half of the students in the concept mapping (51.4%) and co-operative learning (56.1%) groups were able to apply the concept of osmoregulation and excretion to answer questions relating to real life situation, less than half of the students in the lecture method group (37.5%) were able to do so. From this, it could be deduced that since students in the concept mapping and co-operative learning groups negotiated and constructed their own concepts during the lessons, they were able to develop deeper understanding of the topic hence their ability to outscore their counterparts in the lecture method group whom received information organised and presented by the teacher. Moyer, Hackett & Everett [55] opined that science is the dynamic interaction of thought processes, skills and attitudes that help learners develop a richer understanding of the natural world and its impact on society. This implies that any instructional approach in science teaching and learning that prevents students from actively engaged in thought process could hamper their conceptual development and hence they would not be able to apply the concept learned in different setting [56-72].

Conclusion

It can be concluded from the above findings and result that concept mapping and co-operative learning have more positive effects on students' achievement in excretion than the lecture method. Students' achievement of excretion can be enhanced by the use of effective instructional strategy. Also, the use of co-operative learning makes students perform homogeneously as compared with concept mapping and lecture method. Students' correct conception of excretion can be enhanced by effective instructional approach. Lastly, there is no statistical significant relationship between the instructional approaches the students received and their correct conception of excretion.

Recommendations

Based on the findings of this study, the following recommendations are made:

1. It was evidenced in this study that students taught with co-operative learning produced students with high scores, homogeneous performance and ability to apply concept learned to real life situation. In a school where large classes exist, the teacher should make an effort to sub-divide the students into smaller groups and teach the groups using co-operative learning instructional approach. This will help students to fully participate in the lesson and gain deeper understanding of the topic treated.

2. It was indicated in this study that the lecture method also improved students' performance in excretion but with moderate effect size. Therefore, the lecture method could still be used to teach very abstract topics to enable students easily acquire knowledge, new information, and explanation of events or things.

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