EFFECT OF CONCEPT MAPPING ON THE ACHIEVEMENT OF BIOLOGY STUDENTS AT THE SENIOR HIGH SCHOOL LEVEL IN GHANA

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Quality education for all is one of the most powerful and proven vehicles for achieving the Sustainable Development Goals. The purpose of this study was to compare the concept mapping approach which is based on constructivist theory to the traditional method of teaching biology in Senior High Schools. Two intact classes were randomly selected from five Co-educational Senior High Schools offering elective biology in the New Juaben Municipality. The design used was the pretest and post-test nonequivalent quasi design. The sample size was 105 students. The experimental group consisted of 51 students while the control group consisted of 54 students. The students in the experimental group were instructed with concept mapping while the control group were instructed with the traditional method. Both groups were taught the same content which was on photosynthesis and internal respiration. Means, standard deviations, frequencies, Mann Whitney U, independent sample t-test, paired sample t-test were the statistical tools used to analyse the data. The results indicated that those instructed with concept mapping did better than those instructed with traditional method. The study recommends that concept mapping method should be encouraged in many biology classes at the Senior High School

Keywords: Concept mapping, Senior High School Students' Achievement, Photosynthesis, Internal Respiration, New Juaben Municipality, Ghana.

INTRODUCTION

Concept map according to Novak and Gowin (1984) is a schematic device for representing a set of concept meanings embedded in a framework of propositions. It is a two-dimensional hierarchical diagram that illustrates the interconnection between and among individual concepts. To Jonassen (2000), concept map is a visual representation of concepts and their interrelationship. Concept maps also known as cognitive maps or organizers, semantic networks, visual or graphic organizers make use of figures, lines, arrows, and spatial configurations to show how content ideas and concepts are organised and related (Anderson and Huang, 1989) The process of concept mapping involves representing with a diagram the logical relationships among concepts in an orderly, sequential or hierarchical manner such that the most broad or general concepts are at the top and the most specific ones are at the bottom of the map.

The technique of concept mapping was developed by Novak while undertaking his research programme at Cornwall University where he sought to follow and understand children's knowledge in science (Novak and Canas, 2008). It has subsequently been used as a tool to increase meaningful learning in the sciences and other subjects as well as to represent the expert knowledge of individuals and teams in education, government and business. Concept maps have their origin in the learning movement called constructivism. Novak's work is based on the cognitive theories of Ausubel, who suggested that learn meaningfully by building knowledge on the bases of their prior knowledge. Ausubel, (1968, as cited in Novak and Canas 2008) stated that "the most important single factor influencing learning is what the learner already knows, ascertain this and teach accordingly". The fundamental idea in Ausubel's cognitive psychology is that, learning takes place by the assimilation of new concepts and propositions into existing concept and prepositional framework by the learner. This knowledge structure as held by the learner is also referred to as the individual's cognitive structure (Ausubel, Novak, and Hanesian, 1978).

The performance of elective biology students at the Senior High School level continues to be abysmal. Several factors have been identified to be contributing to this underachievement of elective Biology students. These factors include teacher qualification, teacher resourcefulness, and teacher experience (Shaibu and Olarewagu, 2007) inadequate practical lessons (Anthony–Krueger, 2007); class size (Mynt and Goh, 2001); and also students perceiving the subject to involve too much reading (Mucherah, 2008).

Aside the above reasons for students' underachievement, the approach to teaching and learning of Biology has also been identified as a contributing factor. Most teachers in the SHS are still using the traditional techniques of teaching the subject. This seems to cause students to inadequately understand the lessons they are taught hence, might cause them to memorize facts only for examinations and thereafter promptly forgetting what they have learnt.

One teaching approach that is widely used in the Western countries and in this 21st century in presenting science concepts to students is concept mapping. Some studies have revealed that concept maps have been effective for retention and comprehension of concepts, and that there have been significant differences between concept map groups and non-concept map groups (Bunting et al, 2006; Novak and Canas, 2008; Novak and Gowin, 1984; Scagnelli, 2010).

Concept mapping as a method of instruction, however, is not widely used in SHS in Ghana therefore, was designed to compare the concept mapping approach which is based on constructivist Hence the SHS students may not be benefiting from the advantages of concept mapping. This study theory to the traditional method of teaching biology in Senior High Schools.

The objective of the study was to compare the effectiveness of the concept mapping method and traditional method of teaching and learning some biological concepts at the SHS level. The study focused on whether the concept mapping technique could positively affect students' achievement in Biology and also promotes meaningful learning among them. Based on this objective the study formulated the hypothesis that:

H0: *There is no significant difference in achievement of students taught with concept mapping technique and those taught with the traditional method."*
H1: *There is significant difference in achievement of students taught with concept mapping technique and those taught with the traditional method.*

LITERATURE REVIEW

Concept mapping is one pedagogical tool which has gained grounds in the teaching and learning of Biology and other related science subjects in the western countries. Concept mapping has been reported to provide a very effective strategy to help students learn meaningfully by making explicit the links between scientific concepts (Fisher, Wandersee, and Moody, 2000, Novak and Gowin, 1984). It has also been reported that concept maps improve students' problem-solving capabilities and aid collaborative learning (Okebukola, 1992; Sizmur and Osbourne, 1997). A concept map is a tool for showing the conceptual structure of a course discipline in a two-dimensional form which is analogous to a road map. Novak and Canas (2008) explained that concept maps are graphical tools used for organizing and representing knowledge. This includes concepts, usually enclosed in circles or boxes of some type, and the relationship between concepts indicated by a connecting line linking to concepts. Words on the line referred to as linking words or linking phrases specify the relationship between the two concepts.

A concept map is a way of representing relations between ideas or words, in the same way that a sentence diagram represents the grammar of a sentence, a roadmap represents the locations of highways and towns, and a circuit diagram represents the workings of an electrical appliance. In other words, it provides a visual roadmap showing the pathways that we may take to construct meanings of concepts and proposition. It is both a meta– learning and meta–knowledge tool (Novak and Gowin, 1984). Concept mapping is a way to develop logical thinking and study skills; it reveals how concepts are connected. Students not only see connections, but are also able to visualize how larger concept are broken down into simpler ones. A key feature of concept maps is that they are constructed to represent text structure patterns which serve to help students' mental constructs or schemata of how texts are organized. By mapping ideas into maps designed to model text structure patterns, teachers help students to visualize relationships and learn patterns (Bos & Anderson, 1990 cited in Guastello, Beasely, and Sinatra, 2000).

One big advantage of using concept maps is that they provide visual image of the concepts under study in a tangible form which can be focused very easily. They can be readily revised any time when necessary. During the formulation process they consolidate concrete and precise understanding of the meanings and inter-relation of concepts. Thus, concept mapping makes learning an active process, rather than a passive one.

Bunting, Coll, and Campbell (2006) observed that students who attended tutorial using concept mapping achieved significantly higher marks than those who attended a convectional tutorial or no tutorial. However, in test items that did not require sophisticated level of conceptual organisation, there was no significant difference between concept mapping group and non-concept mapping group. Bos and Anders (1990) also found out that Junior High students with learning disabilities who used semantic mapping and semantic feature analysis demonstrated greater comprehension and vocabulary learning than those who received treatment with a traditional approach.

Furthermore, Akpinar and Ergin (2008) taught students on animal cell using interactive computer animation instruction accompanied by teacher and student concept maps, and traditional method. They assert that there was statistically significant difference between the concept map group and the traditional method group in favour of the concept map group. Asan (2007), in his study among fifth grade science students in Turkey, used inspiration which is a computer base concept map to teach the experimental group and traditional method for the control group. It was found that the experimental group achieved significantly higher than the control group. Also, Boujaoude and

Attieh (2008), claim that there was no significant difference found between the experimental and the control groups who were taught chemistry using concept map and traditional methods.

MATERIALS AND METHODS

A pretest-posttest nonequivalent quasi-experimental design was used for the study since the subjects were not to be assigned randomly to the experimental and control groups (Cohen, Manion, and Morrison, 2000; Creswell,1994). In a typical school situation, classes cannot be disrupted or reorganised for the researcher to conduct his study, therefore in such a case, it is better to use groups that are already organized or intact (Ary, Jacobs, and Razavieh, 2002).

The target population for the study was all SHS students taking elective Biology in the New Juaben Municipality. There are six public SHS in the New Juaben Municipality. Five schools are co-educational and one is a single sex school. It was estimated that about 2000 students take elective Biology in the New Juaben Municipality. However, the accessible population was SHS 3 elective Biology students in the New Juaben Municipality whose population was 500. The students admitted into the schools in the New Juaben Municipality are from various parts of the country, with different socio-economic backgrounds; hence the population for the study would have characteristic features of SHS students in all parts of the country.

Sample and Sampling Procedure

The sample was comprised of two Senior High Schools (SHS) in the New Juaben Municipality. Out of the six SHS, five are co-educational. Two schools were randomly sampled from the five co-educational schools. The school selected first was assigned as the experimental group (thereafter named A for anonymity) and the school selected second was assigned the control group (thereafter named B for anonymity). SHS 3 students were also selected purposively for the study, because the concept of respiration and photosynthesis which are some of the difficult concepts for students' comprehension are treated in SHS 3 as the elective Biology syllabus demands. The experimental group was made of 51 students while the students in the control group were 54 in number.

Data collection Instrument

The instrument used for the study was the Biology Achievement Tests BAT). The Biology Achievement Test (BAT) which comprised four essay test items was used as the pretest and posttest for both the control and experimental groups. Each question had three sub- questions. Sub-question 'a' consist of comprehension questions, sub-questions 'b' consists of application questions while sub-questions 'c' consists of analysis questions. BAT has a total score of 80; the comprehension question items had a total score of 27; application questions has a total score of 27 and analysis questions 26. The pretest was used to ascertain the level of knowledge the students have on photosynthesis and respiration and to determine the homogeneity or the heterogeneity of the control and experimental groups and also to know the level of knowledge each group has on photosynthesis and respiration before the intervention is given. Students have had lessons on photosynthesis and respiration in their second year in integrated science. The posttest was administered after the treatment had been given. Students' achievement or performance in the posttest was compared between the experimental and the control groups.

The test items were developed based on SHS Elective Biology Syllabus and textbooks, and some modified past questions of the West African Examinations Council (WAEC). To ensure content and face validity of the instrument, the test items were subjected to expert judgment by renowned science education lecturers in the Department of Science and Mathematics Education, and their corrections and suggestions were used to improve upon the instruments. To ensure internal consistencies of the achievement tests, the assistance of two raters were sought, one for BAT pretest and another for the posttest. The raters have about 6-8 years of teaching experience as Biology tutors and are also assistant examiners of the West African Examination Council. The raters and I discussed the scheme and agreed on the marks awarded. Eight photocopies of the students' script were marked as dummies and the scores compared and the differences analysed before the live scripts were given out. Eight days were spent in marking the scripts.

The content validity of the instruments was determined by subjecting them to expert judgment (Lomask, Jacobson and Hafner, 1995). By this, the instrument (BAT) was subjected to inspection by experts including two supervisors, some science education lecturers, Master of philosophy and Doctor of philosophy (science education) students, two SHS Biology teachers who had 5-8 years of teaching experience for their judgments on the content and the level of language; while the interrater reliability of BAT1 pretest was 0.99 and posttest was 0.99.

Data collection procedure

Letters of introduction from the Department of Science and Mathematics Education (DSME) of the Faculty of Education were sent to the headmasters of schools where the research took place. I met the headmasters of the respective schools who after explaining the rationale of the study to them introduced me to the respective heads of science departments. I was then introduced to the teachers handling SHS 3 Biology by the heads of the science departments. This was followed by interactions with the SHS 3 Biology teachers to know from them the methods they most often used for teaching the students in their respective classes. It was revealed that the method mostly adopted by these teachers for teaching was the traditional method where the lesson is introduced followed by an expository explanation. Students also had to write copious notes given by the teacher. I took time to observe the teachers teach, but this was done with their consent; this helped me to know how to exactly teach the control group. I also took time to familiarize with the students as well. The rapport which was created between the teachers and the students created a congenial atmosphere throughout the period of data collection. During the familiarization, the experimental group was introduced to concept mapping. The topic 'cell' was used to teach students the stages of concept mapping. 'Cell' was not part of the topics to be treated in the main study. This topic was chosen because it was treated in the first year of SHS 1 and this served as revision for them. Students were given photocopies of a researcher-made concept map of the cell (Appendix A). The explanation was mainly centred on linkages between concepts (propositions) and the hierarchical arrangement of concepts on the concept map. I gave students various exercises to make them conversant with concept mapping. The control group were also were taught the same topic. Students were briefed on how they could understand lessons taught using the expository method. They were told to pay attention to the voice variation of the teacher and certain phrases like, 'the most important factors are…' 'the two main stages are…''there are two main types of...'; 'The following are...', 'the differences are…' and 'in conclusion…' etc.

At the end of the five days of familiarization, a pretest on the Biology achievement test (BAT) was administered to both the control and experimental groups. The test comprised items on the topics - photosynthesis and internal respiration. Time allocation for the pretest was two hours. Students were encouraged to do independent work.

After the pretest, the treatment followed. Students in both the control and the experimental groups were taught for two weeks. I, being a qualified Biology teacher taught both groups. Researcher bias, which is often associated with this type of design, was thought to be a risk worth taking.

The treatment covered four days for each group during which each class met for 80 minutes for each day. The experimental group had Biology on Monday 10:30 – 11:50 and on Wednesday 11:50 – 1:10 while the control group had Biology on Tuesday 7:40 – 9:00 and on Thursday 1:10–2:30. The flexibility of the time Table made it possible for commuting between both schools by the researcher easier. I went to the experimental school first followed by the control group the following day. I alternated between both schools based on the Time Table. Hence, I visited each school two times a week for four weeks. The first week was for familiarization, the other two weeks were for teaching the topics and the last week was for administration of the achievement posttests, questionnaire and the interview. Both the control and the experimental group were taught the same content, had the same instructional objectives, same lesson duration and class assignment. Both groups were taught on the units of photosynthesis and internal respiration.

Students in the experimental group were put into groups each comprising four members. Each group selected its leaders comprising the group leader and the secretary. The groups facilitated collaborative learning and allowed students to agree on consensus concerning the tasks assigned. Groups under the supervision of the researcher constructed micro concept map on various sub-concepts. Each group presented their maps to the class for scrutiny and inputs to be made.
After the intervention, the posttest was administered to both groups under strict examination conditions.

DATA ANALYSIS

The scores from pretest and posttest in BAT were subjected to descriptive and inferential statistics. Descriptive statistics used include mean and standard deviation, frequencies and percentages. Furthermore, histograms and box plots were drawn and normality was tested using Kolmogorov-Smirnov test statistics. The normality of the pretest of Kolmogorov-Smirnov value of 0.035 at p = 0.05 showed that the data is not normally distributed. The normality of Kolmogorov-Smirnov value of 0.200 for posttest (BAT) showed that the data is normally distributed. Depending on the result of the normality test, the statistical tools, Mann Whitney U, t–test, which allows for the testing of the statistical significance at 0.05 alpha level were employed for the analysis of data. Mann Whitney U Statistics was used to compare the pretest mean scores in achievement for the experimental and control groups to ascertain the entry behaviour of the students. Also, independent sample t-test was used to compare the posttest mean scores in BAT between the experimental and control groups in order to test the hypothesis.

RESULTS

Difference in Achievement between Students Taught with Concept Mapping and those Taught with the Traditional Method

Preliminary analysis was done by comparing groups' scores from the pretest using Mann Whitney U test. Mann Whitney U test was used because the normality test had a Kolmogorov-Smirnov value of 0.035, which indicates the data is not normally distributed. Results of comparison of pretest scores between the experimental and control group is presented in Table 1.

Table 1: Results of comparison of pretest scores between the experimental and control group

Group	N	Mean Rank	Z	p
Experimental	51	53.14	-.045	0.964*
Control	54	52.87		0.001*

** Significant at 0.05 Maximum score = 80*

Results from Table 1 show that there was no statistically significant difference between performance of students in the experimental group and control group (Mann Whitney U z = 0.045, p = 0.964) in the BAT before instruction. The mean ranks which are the averages of the ranks of the scores of both groups respectively also showed that both the experimental and the control groups performed almost at the same level. This indicates that students in both groups had similar knowledge about photosynthesis and internal respiration which were the Biology content examined in this study before the interventions were given.

Also paired sample t-test was conducted to see the effect of the intervention on each group and this has been presented in Table 2.

Table 2: Results of Dependent Sample T-Test for Pretest and Posttest Scores

Group	Variables	N	Mean	SD	t	p
Experimental	Pre-test	51	12.53	5.697	17.364	0.001
	Post- test	51	35.25	12.959		
Control	Pre-test	54	12.57	6.762	17.053	0.001
	Post-test	54	25.80	10.113		

t- value significant at .05 Maximum score 80

Table 2 shows a statistically significant difference between the two groups' pretest and posttest scores. The experimental group's mean for posttest (M= 35.25, SD= 12.959) was significantly higher than its mean scores for retest (M = 12.53, SD = 5.679; t (50) = -17.364, p = 0.001). The magnitude of the difference in mean was very large with a standard effect size index of 2.43. According to Green, Salkind and Akey (1997), an effect size of 0.20 is small, 0.50 is moderate and 0.80 is large. Also the control group's mean from posttest (M= 25.80, SD= 9.360) was significantly higher than its pretest (M =12.57, SD = 6.762; t (53) = -17.053, p =0.001). The effect size of 2.30 was also very large.

To investigate the difference in post-test scores between the experimental and the control groups, the mean scores were compared using independent sample t-test. Independent sample t-test was deemed appropriate because the data showed normal distribution with Kolmogorov-Smirnov value of 0.200. Results of independent sample t-test for the post-test for both the experimental and the control groups are presented in Table 3.

Table 3: Results of BAT Post-test of Experimental in Control Groups

Group	N	Mean	SD	t	p
Experimental	51	35.25	13.05	4.193	0.001*
Control	54	25.80	9.95		

t-value significant at 0.05 Maximum score = 80

As shown in Table 3, there was statistically significant difference between the mean scores of experimental (M = 35.25, SD = 13.053) and control (M=25.80, SD =9.953; t (103) = 4.193, P= 0.001). The concept mapping group achieved significantly higher than the traditional method group—an effect size of 0.82. According to Green, Salkind and Akey (1997) effect size of .20 is very small, .50 is moderate and .80 is largeTherefore the null hypothesis is rejected. Figures 1 and 2 in Appendix show samples of marked scripts of the post-test of both the experimental and controlled groups.

The two scripts were randomly sampled. In order to hide students' identity their names were not written on the scripts, but rather their codes. The scripts were marked by the researcher and another rater. The scores obtained by students of both groups show that the experimental group performed higher than the controlled group.

DISCUSSION

The study compared the effectiveness of the concept mapping method and traditional method of teaching and learning of some biological concepts at the SHS level. The study focused on whether the concept mapping technique could positively affect students' performance in two biological concepts— *photosynthesis and respiration.* The results of the study rejected the null hypothesis and upheld the alternate hypothesis. The students exposed to concept mapping performed better than their counterparts exposed to the normal traditional method of teaching.

Both the concept mapping and traditional approaches to teaching had significant effect on students' performance. The large difference in mean scores for the experimental group indicates that when concept mapping is used as an instructional strategy in teaching photosynthesis and internal respiration, students easily grasp the concepts. The corresponding increase in the mean score of the control group also showed that they also understood the concept of photosynthesis and internal respiration.

Students exposed to concept mapping performed better than their counterparts exposed to the normal traditional method of teaching. Bunting et al (2006) observed that students who attended tutorial using concept mapping as an instructional strategy achieved significantly higher than those who attended a convectional class or no tutorials. In similar works by Asan (2007) and Akpinar and Ergin (2008), students taught with concept map had significantly achieved higher than their counterparts taught with the traditional method.

These works give clear evidence attesting to the ability of concept mapping in promoting students' performance in Biology. The links and interrelationships among the concepts as depicted in the concept mapping might have made the students in the concept mapping group learn more meaningfully. According to Ausubel (1968 as cited in Novak and Canas, 2008), meaningful learning is promoted by the understanding of the hierarchical relationships and linkages between concepts.

Guastello et al, (2000) asserted that students who use concept map are able to learn to translate ideas from text to visual graphic arrays that display whole relationship of content ideas. Similarly, Bos and Anders (1990 as cited in Guastello et al, 2000) indicated that such graphic plans or presentations serve to help students make mental constructs or schemata on how texts are organized. By mapping ideas into maps designed to model text structure patterns, teachers help students to visualize relationships and learn structures.

The significant difference in achievement between the experimental and the control groups shows the capabilities that lie in the concept mapping as a method to improve teaching and learning in Biology classrooms. The students in the experimental group were able to see links among concepts and this boosted their comprehension on topics which they were taught. Also, the social constructivist approach used in concept mapping is an added advantage of providing an incentive which influenced students understanding. Students' ideas were fully involved in the construction of concept maps to encourage them and also help them to see links. The lists of concepts were generated by the teacher in conjunction with students input.

Students were put into groups of four to construct concept maps. As they constructed, they shared ideas, and the best ones were taken for the construction of their maps; as indicated by Anamuah-Mensah, Otuka, and Ngaman- Wara (1996) this idea, became a public knowledge. Students were also made to construct concept maps individually. As they made links between one concept and another, they created their own knowledge. Also students recording their ideas in a concept map meant they had visual representation of the concept being discussed, and the linking term made the relationship between concepts explicit (Bunting et al, 2005).While students were constructing maps (either individually or in groups) the research who was also the instructor moved around the class and used the time to discuss and comment on their maps. The concept maps were marked and returned to students on time which gave students constant feedback. This attention and formative feedback might have served as a motivation for them and made them focus on relevant portions of content taught.

In contrast, these feedbacks, comments from instructor and sharing of ideas from students were lacking in the control group who were taught the traditional way of teaching. However, the manner in which the traditional method was used for instructions helped students to perform well. For instance, voice was audible enough; there was good voice variation to give clues to students. Students were made to take clues from some phrases such as *'there are two main types of...'; 'The following are 'the main stages of.....',* '*the differences are…' and 'in conclusion …*'. Also, language was at the level of students, the pace of the lessons was such that students could cope, and students' attention was sustained throughout the lessons. Students were also taught how to answer questions involving the various cognitive levels. Also, because the control group was in most cases instructed after the experimental group, there would be improvement in teaching the same content. These might have helped them to improve in the BAT.

As concept map give students' visual representation of concepts, they could retain information easily. Sperling (1963) referred to these as iconic memories. Shepard (1967) indicated that higher percentage of students who were instructed using graphical and pictorial presentation were able to remember facts presented to them at a later time than those who were not.

Students in the concept mapping group might have learnt meaningfully because of the hierarchical, logical and sequential presentation of concepts. Ausubel (1968 as cited in Novak and Canas, 2008) asserted that, for meaningful learning to occur the new ideas must have potential meaning and the learner must possess relevant concepts that can anchor new ideas. The learner must also consciously relate the new ideas or verbal propositions to relevant aspects of their current knowledge structure in a conscious manner. According to Ausubel, meaningful learning occurs by the process of subsumption when potentially meaningful propositions are subsumed under more inclusive ideas in existing cognitive structure. The new propositional meanings are hierarchically organised with respect to the level of abstraction, generality and inclusiveness.

Novak and Gowin (1984) pointed out that concept maps rely on three fundamental qualities: hierarchical structure, progressive differentiation and integrative reconciliation. Novak (1990) emphasized that, during concept mapping, the learner graphically represents concepts in hierarchical arranged structure and begin to progressively differentiate among concepts. By progressive differentiation, Novak meant the learning process in which learners differentiate between concepts as they learn more about them. During integrative reconciliation, the learner views relationships between concepts and does not compartmentalize them. Illustrating integrative reconciliation requires connection among concepts, both super ordinate and subsumed, as well as between concepts which may be on different branches, yet the same level.

Starr and Krajcik (1990) noted that integrative reconciliation can be assessed by considering the quality of verbal links between concept maps. Boujaoude and Attieh (2008) asserted that concept mapping presented the students a novel experience making them active in the process of identifying links between concepts. Novak, (1990), Novak and Wandersee (1991) and Novak & Canas (2008) believe that one of the reasons concept mapping is so powerful for the facilitation of meaningful learning is that it serves as a kind of template or scaffold to help to organise knowledge and to structure it, even though the structure must be built up piece by piece with small units of interacting concept and propositional frameworks. These capabilities in concept mapping could be the reasons behind the higher achievements in the experimental group.

CONCLUSION AND RECOMMENDATIONS

The results of the study provided holistic understanding of the importance of concept mapping strategy in the teaching and learning of biological concepts. From the findings discussed above, we could conclude that there were statistical significant differences in performance between the experimental and the control groups in favour of the experimental group. These results therefore showed that using concept mapping in presenting biological concepts to students at the SHS level is not only more effective than the traditional method, but it also has the ability to improve students' achievements in Biology. Finally, the concept mapping strategy makes students learn meaningfully to improve upon their performance.

These findings have significant implications for practice and policy makers (curriculum planners) trying to improve quality of teaching and learning at the SHSs level. For practice, concept mapping is worth adopting as a teaching strategy by Biology teachers at the SHS level because of its effectiveness in enhancing students understanding of biological concepts and its relevance in giving students the opportunity to see links between concepts, summarise and organise their works and thoughts logically and sequentially. For policy, the study recommends that the curriculum planners should include concept mapping as pedagogical content knowledge when designing the curriculum for SHS grades.

However, there are limitations to this study. The responses were collected from only two SHSs, thus caution is essential in generalizing the findings to the entire SHSs in the Country, especially within the context of private SHSs which have different students' academic and demographic profile compared to public SHSs. Future studies should be expanded throughout the other SHS in the country, including private SHS, to allow for the generalizability of the findings.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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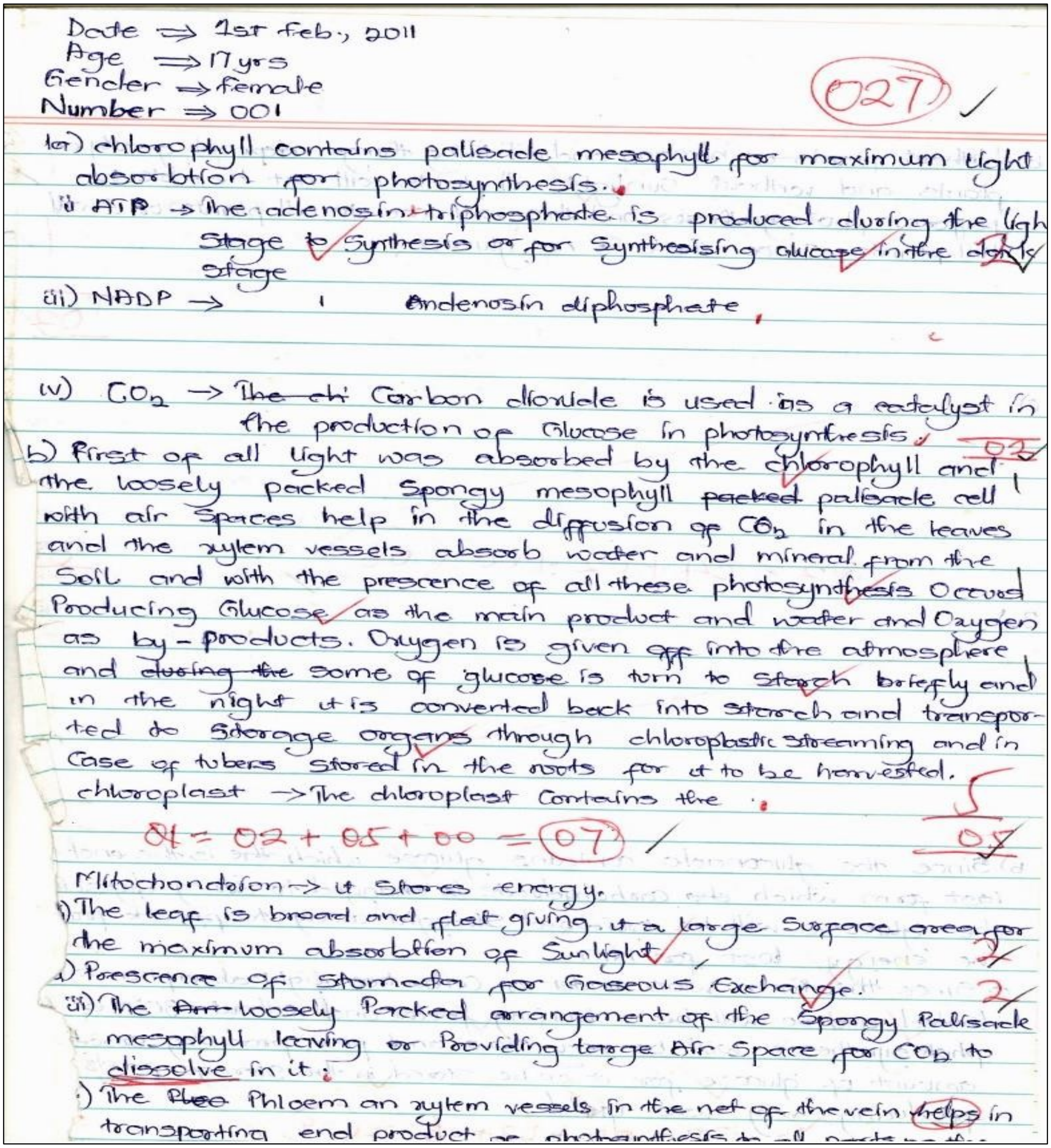
Appendix


Date ⇒ 1st feb., 2011
Age ⇒ 17 yrs
Gender ⇒ female
Number ⇒ 001

(027) ✓

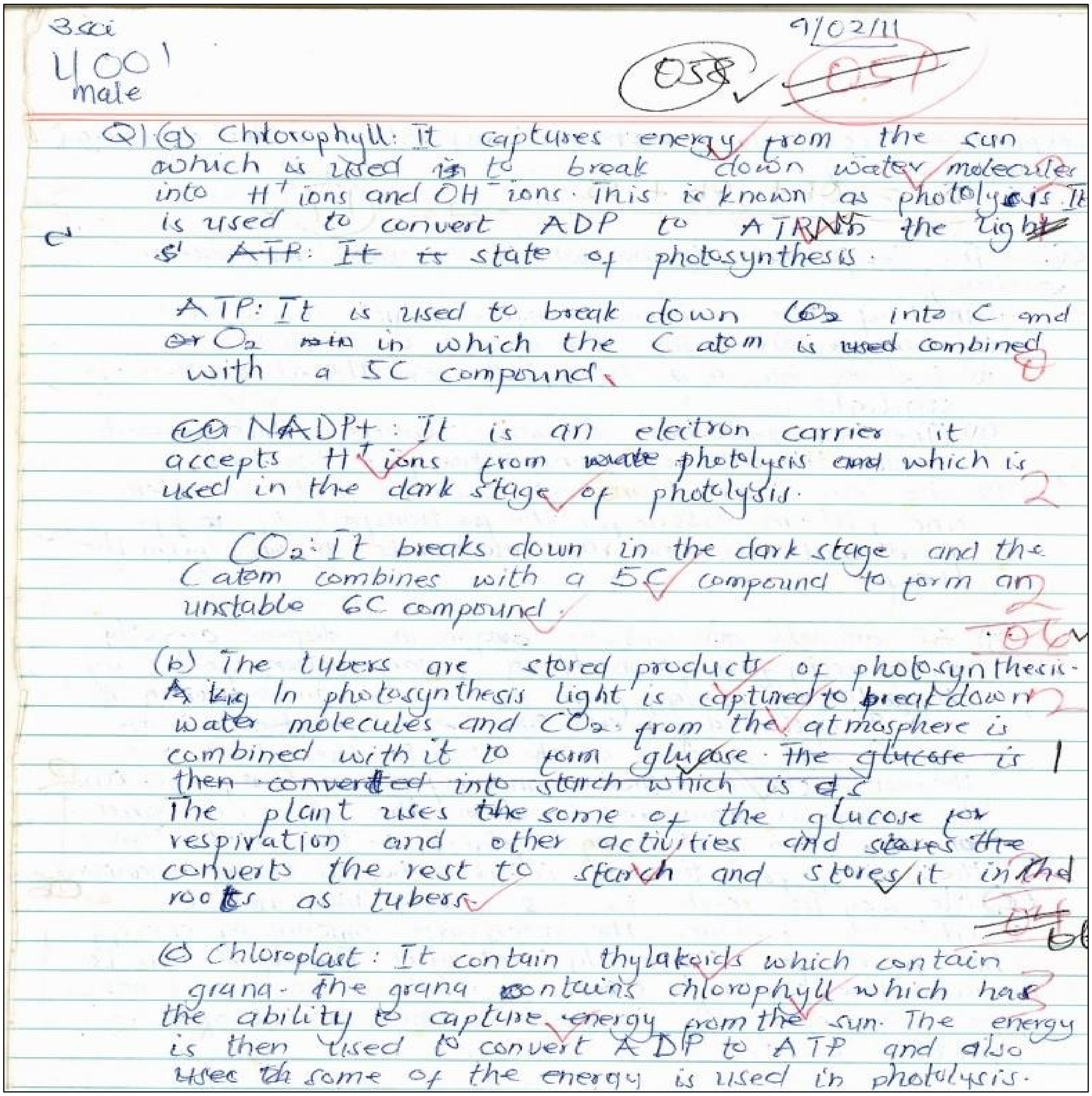
1a) chlorophyll contains palisade mesophyll for maximum light absorbtion for photosynthesis.
ii ATP → The adenosin triphosphate is produced during the light stage to synthesis or for synthesising glucose in the dark stage
iii) NADP → Andenosin diphosphate,

iv) CO_2 → The Carbon dioxide is used as a catalyst in the production of Glucose in photosynthesis. 02
b) First of all light was absorbed by the chlorophyll and the loosely packed spongy mesophyll palisade cell with air spaces help in the diffusion of CO_2 in the leaves and the xylem vessels absorb water and mineral from the soil and with the prescence of all these photosynthesis Occured Producing Glucose as the main product and water and Oxygen as by-products. Oxygen is given off into the atmosphere and some of glucose is turn to starch briefly and in the night it is converted back into starch and transported to storage organs through chloroplastic streaming and in case of tubers stored in the roots for it to be harvested. 5
chloroplast → The chloroplast Contains the 0

Q1 = 02 + 05 + 00 = (07) ✓

Mitochondrion → it Stores energy.
i) The leaf is broad and flat giving it a large surface area for the maximum absorbtion of Sunlight 2
ii) Prescence of Stomata for Gaseous Exchange. 2
iii) The loosely Packed arrangement of the Spongy Palisade mesophyll leaving or Providing large Air Space for CO_2 to dissolve in it.
) The Phloem an xylem vessels in the net of the vein helps in transporting end product of photosynthesis to all parts of the...

Figure 1: Sample of marked script of post-test of control group


3sci
400
male
9/02/11
058 057
Q1(a) Chlorophyll: It captures energy from the sun which is used to break down water molecules into H^+ ions and OH^- ions. This is known as photolysis. It is used to convert ADP to ATP the light
ATP: It is state of photosynthesis.

ATP: It is used to break down CO_2 into C and O_2 in which the C atom is combined with a 5C compound.

NADP+: It is an electron carrier it accepts H^+ ions from photolysis and which is used in the dark stage of photolysis.

CO_2: It breaks down in the dark stage and the C atom combines with a 5C compound to form an unstable 6C compound.

(b) The tubers are stored products of photosynthesis. In photosynthesis light is captured to break down water molecules and CO_2 from the atmosphere is combined with it to form glucose. The glucose is then converted into starch which is ... The plant uses some of the glucose for respiration and other activities and converts the rest to starch and stores it in the roots as tubers.

(c) Chloroplast: It contain thylakoids which contain grana. The grana contains chlorophyll which has the ability to capture energy from the sun. The energy is then used to convert ADP to ATP and also some of the energy is used in photolysis.

Figure 2: Sample of marked post-test script of experimental group