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**EFFECT OF CONCEPT MAPPING INSTRUCTIONAL STRATEGY
ACCOMPANIED BY DISCUSSION WEB ON STUDENTS' ACADEMIC
ACHIEVEMENT IN THE CONCEPT OF GENETICS**

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EFFECT OF CONCEPT MAPPING INSTRUCTIONAL STRATEGY ACCOMPANIED BY DISCUSSION WEB ON STUDENTS' ACADEMIC ACHIEVEMENT IN THE CONCEPT OF GENETICS

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Abstract

Purpose: This study explored the effect of Concept Mapping Instructional Strategy Accompanied by Discussion Web on students' academic achievement in the concept of Genetics at Navrongo Senior High School, generally, and on gender basis.

Methodology: The study adopted quasi-experimental design (pretest, posttest non-equivalent design). The sample comprised of 80 Navrongo Senior High School Form Three Gold Track and Green Track science students. Students from the Green Track class and Gold Track class were assigned experimental group and control group respectively. The experimental group class was made up of 23 males and 20 females. The control group class was also made up of 24 males and 13 females. Pretest was administered to all the participants. The experimental group was taught using Concept Mapping Instructional Strategy Accompanied by Discussion Web. The control group was taught using Conventional Teaching Method. A posttest was administered to both groups to determine the effectiveness of the treatment. The reliability of the test items was determined using test-retest reliability coefficient. The test-retest reliability coefficients of the instruments were found to be 0.70 and 0.73 for the pretest and posttest respectively. The data obtained were analysed using t-test.

Results: The pretest test scores revealed that the students were homogeneous in terms of academic achievement (t -value = 1.05, p -value=0.30, $p > 0.05$). Posttest results of students in the experimental group were significantly higher than the control group (t -value = 8.07, p -value = 0.000, $p < 0.05$). The result of the posttest showed that the use of concept mapping instructional strategy accompanied by discussion web in teaching genetics was more effective than conventional teaching method. There was no statistically significant difference in the academic achievement of male and female students in the experimental group (t -value = 1.68, p -value = 0.11, $p > 0.05$).

Unique contribution to theory, practice and policy: This study recommended that Biology teachers in Navrongo Senior High School should be encouraged to teach Genetics using Concept Mapping Instructional Strategy Accompanied by Discussion Web in order to improve the academic achievement of students. Science teachers should be given the opportunity to attend workshops, seminars, conferences to enable them update their knowledge on current instructional

strategies that are capable of improving the academic achievement of students. The Government, Ghana Education Service and Ministry of Education should establish professional development fund for teachers to enable them upgrade professionally and also improve on their teaching styles since most teacher are not abreast with the current or modern methods of teaching.

Keywords: *Genetics, Concept Mapping, Discussion Web, Conventional Teaching Method*

1.0 INTRODUCTION

The impact of science education in the growth and development of a nation cannot be over emphasized. Science is the method of obtaining knowledge through investigation, experimentation, observation and drawing of conclusion. According to Satyaprakasha and Behera (2014) this method involves observation and experimentation to describe natural phenomena. Biology is an aspect of science that deals with the study of living things. Biology is a subject that is offered at the Senior High School level to tertiary institutions in Ghana. The method used by teachers in teaching this subject at the senior high level does not help to improve the academic achievement of students. The most common instructional methods used by Biology teachers are; lecture method, demonstration method and note-taking. These methods stress upon only naming, recalling and memorizing but does not help to improve the critical and inquiry skills of learners (Singh & Moono, 2015). The traditional method of teaching makes the learner less active in the teaching and learning process (Umar, Dauda, & Mutah, 2016). The inappropriate teaching methods adopted by facilitators are the main causes of poor performance and poor achievement of students in biology and other science subjects (SMASSE, 2012). According to Ogunkola and Samuel (2011) one of the main factors in facilitating meaningful learning of biological concepts is the use of effective and efficient pedagogy by teachers. Biology teachers in Ghana and across the globe need to adopt instructional strategies that are capable of improving the academic achievement of students. Students' academic achievement describes the extent to which learners accomplished specific goals that were the focus of activities in instructional environments specifically class, school, college and university. In Ghana, students' academic achievement is often measured through examinations or school based assessments. The academic achievement of learners enables facilitators to know whether their methods of teaching were effective or not and hence helps them to improve (Alyahyan & Düştegör, 2020). It also provides learners with the opportunity to develop their talents, improves their grades and prepare them for future challenges.

There are varieties of current instructional methods that would promote better understanding of scientific concepts. These methods include; project-base learning, inquiry method, fieldtrip method, multimodal method, computer assisted instruction, Laboratory method and Concept mapping method (Namale & Buku, 2011). These methods give opportunity to learners to participate fully in the teaching and learning process (Olufunminiyi, 2015). Certain instructional techniques will be use to achieve the stated instructional objectives than others. The inquiry or discovery method will be more effective for teaching problem solving skills than discussion or demonstration method (Azure, 2018). Similarly, laboratory method will be the appropriate method

for teaching practical skills. Also, selecting a teaching method, strategy, technique or approach for teaching in Biology, the facilitator should consider the topic to be taught.

Concept mapping instructional strategy accompanied by discussion web could be effective in enhancing the understanding and academic achievement of students in the concept of genetics. The understanding of genetics will help students know much about differences in traits among individuals, sex linkage and sex determination in humans, Blood groups in man and how characteristics are passed on from parents to offspring. According to Agboghoroma and Oyovwi (2015), to effectively teach and meaningfully learn genetics, concepts mapping instructional strategy has been recommended as a vital tool to improve the students' performance in Biology especially genetics.

Concept mapping (CM) is a schematic representation of concepts and their inter-relationship often in a framework that appear like a flow chart (Okafor, 2016). The method of concept mapping was originated and used by Joseph D. Novak and his investigation group at Cornell University, New York, United States in 1970. Concept mapping is a metacognitive learning strategy used in measuring individual's knowledge structure and organization in a specific domain of knowledge (Awofala, 2011). The pedagogical use of concept mapping is to help students learn subject matter more meaningful in science (Emmanuel, 2013). The application of concept mapping approach enables knowledge to be structured and integrated in a hierarchical order (Chiou, Lee & Liu, 2012).

According to Olajengbesi and Aluko (2008) CM is an instructional strategy that involves graphical or diagrammatical representation of concepts achieved by selecting and arranging concepts from lesson into meaningful hierarchy, showing relationship between levels and among concepts. This method of instruction helps learners to present abstract concepts in a concrete way and to clarify the relationships between concepts and facts and to connect new information and prior knowledge (Wang, 2019). Concept maps allow prior experience and understanding to be taken into consideration when building new concepts into the perceptual framework (Shakoori, Kadivar, & Sarami, 2017). CM instructional approach allows a person to convey meaning and relationship to another person in visual manner. It is a useful technique that promotes meaningful learning (Chiou, Lee, Tien & Wang, 2017). Concept mapping instructional strategy is a vital tool that provides a platform for learners to share knowledge of a particular domain and get meaningful understanding of new concepts (Githae, Keraro, & Wachanga, 2015)

Discussion web is a great way to engage students in a meaningful conversation and spark critical thinking at the same time (Guzzetti, 2000). Discussion webs help learners to organize their thinking, examine and learn tolerance for other points of views and draw richer understanding from the materials they read (Yenilmez & Tekkaya, 2006). It gives learners more opportunities to interact. Discussion webs encourage active participation by shy, quiet and slow learners in the class. In discussion web, students think individually about the ideas they want to contribute to the discussion and then discuss these ideas with others (Alkhalwaldeh, 2013). Discussion in a class is intended to be a free give and take between teacher and students and among students on the current topic of concern in the subject (Radman, Khalil, Jumani, Ajmal, Malik, & Sharif, 2011).

1.1 Statement of the Problem

This study investigated the effect of concept mapping instructional strategy accompanied by discussion web on students' academic achievement in the concept of genetics. Genetics is considered as a difficult topic by science students at Navrongo Senior High School in the Kassena Nankana Municipality. Low academic achievement of students at Navrongo Senior High School in genetics was observed by the researcher for a period of three years but a detailed item analysis was performed during 2020 mock exams. When the researcher performed an item analysis on the mock exams Biology paper two (theory paper), only 30% of the total population who sat for the paper answered questions on genetics and out of 30%, only 15% answered genetics questions correctly. The students were asked to give reasons for not responding to question on the topic and majority of the students categorically stated that the topic is difficult and has many technical terms or concepts with a lot of rules making it tedious for them to understand. The West African Examination Council Chief Examiners' Report (WAEC, 2017) stated that candidates who attempted questions on genetics could not state the genotypes of father. WAEC Chief Examiners' Report (2015 & 2016) comments on students' achievement on genetics were very poor. Conclusively, candidates achieved very low on questions of genetics.

According to Ruth and Apawu (2020), the problem of low achievement of students on genetics is due to lack of professional skills for teaching some biological concepts and the persistent use of lecture method of teaching. Nworgu (2012) also posited that the problems associated with students' low achievement in genetics were students lack of interest and inability to retain concepts learnt on genetics. The poor performances in genetics, will lead to decrease in students' interest to go into Genetic Engineering, Medical Genetics, Molecular and Cell Biology courses at the tertiary level (Onyejekwe, Uchendu, & Tochi, 2016). This study therefore set to examine if concept mapping instructional strategy accompanied by discussion web could improve the academic achievement of students in the concept of genetics at Navrongo Senior High School in the Kassena Nankana Municipality in the Upper East Region of Ghana.

1.2 PURPOSE OF THE STUDY

This study was conducted to investigate the effect of concept mapping instructional strategy accompanied by discussion web on form three general science students' academic achievement in the concept of genetics at Navrongo Senior High School.

1.3 Specific Objectives of the Study

The objectives of the study were to:

1. Determine the difference between the pretest mean scores of students in the experimental and control groups.
2. Determine the difference between the posttest mean scores of the experimental and control groups.
3. Examine the difference between the pretest and posttest mean scores of male and female students in the experimental group.

1.4 Research Questions

The following research questions were addressed in the study:

1. What is the difference between the pretest mean scores of students in the experimental group and the control group?
2. What is the difference between the posttest mean score of the experimental group and the control group?
3. What are the differences between the pretest and posttest mean scores of male and female students in the experimental group?

1.5 Research Hypotheses

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

HO₁. There is no significant difference between the pretest mean scores of students in the experimental group and the control group.

HO₂. There is no significant difference between the posttest mean score of students in the experimental group and those in the control group.

HO₃. There is no significant difference between the pretest and posttest mean scores of male and female students in the experimental group.

2.0 LITERATURE REVIEW

2.1 Theoretical review: Constructivism Teaching and Learning Theory

The theory that underpinned this study is the constructivism teaching and learning theory proposed by John Dewey in 1933 and other cognitive constructivists such as Piaget, Bruner and Vygotsky. Constructivism is an innovative strategy in which students construct knowledge themselves through interaction with each other on the basis of previous knowledge (Sharma & Poonam, 2016). Constructivism concept means encouraging students to use techniques such as experiment and real-world problem solving to create more knowledge and then reflect on and talk about what they are doing and how their understanding is changing (Wonkyi & Adu, 2016).

The constructivism theory of learning emphasizes that learning is an active process whereby students construct new ideas based on their previous knowledge and understanding. Effective teaching enables students to make connections of the old and the new knowledge to form new ideas (Faryadi, 2015). Constructivists assert that when learners make use of the information, ideas or concepts they receive from teachers by building up knowledge, then their thinking changed totally from acquisition of knowledge to construction of knowledge. The constructivist teaching and learning theory advocates a participatory approach in which students actively participate in the teaching and learning process (Fernando & Marikar, 2017). The primary responsibility of the teacher is to create a collaborative problem solving environment where students become active participants in their own learning (McLeod, 2019). The teacher acts as a facilitator instead of dictator during teaching and learning process. The teacher makes sure that he/she understands the students pre-existing conceptions and guides the activity to address them (Oliver, 2000). Constructivists' shares a focus on the learner-centered approach and the density of the learner's

cognitive course of action for their learning and support needs and the value of providing learners with opportunities to make meaning and real dynamic contributors in the learning-teaching experience (Bhutto & Chhapra, 2013). According to the Graduate Student Instructor (GSI) teaching and learning resource Centre (Shimamura & Kiristrom, 2016); Cognitive constructivism states that knowledge is something that is actively constructed by learners based on their previous knowledge and Cognitive methods aim to help learners in assimilating new ideas or concepts to existing knowledge and enabling them to make appropriate modification to their existing intellectual framework to accommodate the ideas and concepts.

Fundamentally, constructivist says that people construct their own knowledge and understanding of the world through experiencing things and reflecting on those experiences (Thirteen Ed Online, 2004). According to Fernando and Marikar (2017), the claims of constructivist teaching and learning theory are: a) Learning is an active experience, b) The ideas students hold about a topic or subject being taught will form part of their learning experiences and c) Learning is socially and culturally rooted.

Constructivism encourages instructors to provide each student preferred learning styles, rates of learning and personal interaction with other learners (Christie, 2005). In constructivist environment, learners need to be involved and active within a democratic classroom atmosphere while collaboration is mainly a contributing element in the learning process as well as a student centered approach (Alanazi, 2016).

Tam (2000), listed four characteristics for a constructivism learning environment; i) Knowledge is shared between teachers and students. ii) The teachers' role is one of a facilitator. iii) Teachers and students share authority and iv) Learning groups consist of small heterogeneous students.

2.1 Empirical review

Awofala (2011) investigated the effect of concept mapping strategy on students' achievement in junior secondary school mathematics. 95 students from two intact classes were used for the study. The results of the study proved that there was a significant difference between the posttest mean score of students in the experimental group and their counterparts in the control group. Okafor (2016), investigated the effect of concept mapping and outline note-taking in students' academic achievement in geography in secondary school in Enugu South Lga of Enugu State. 225 students were sampled for the study. The findings of the study proved that the experimental group achieved significantly higher than the control group. Singh and Moono (2015) also investigated the effect of concept mapping on students' achievement on selected topics in chemistry at tertiary level. A total of 39 students were sampled for the study. The finding of the study proved that students who were taught using concept mapping achieved higher than their counterparts who were taught using traditional teaching method.

Also, Joel and Kamji (2016) also explored the efficacy of concept mapping instructional strategy in remedying students' problem-solving difficulties in stoichiometry. A sample of 60 participants were selected for the study. The findings of the study revealed that there was no significant difference between the posttest mean scores of male and female students taught using concept mapping instructional strategy. Contrary to the finding of Joel and Kamji (2016); Adeniran, Achu and Atoo (2018), explored the effect of concept mapping strategy on students' retention in basic

science with a sample of size of 1384 consisting of 665 males and 719 females. The results of the study revealed that females gain slightly higher in retention scores compared to the males.

2.2 Research Gaps

Few studies have been conducted across the continent and the globe at large which include; “effectiveness of concept mapping base teaching methods on grade eight students’ conceptual understanding of photosynthesis at Ewket Fana primary school, Bahir, Dar, Ethiopia” by Woldeamauel, Abate and Berhene (2020), “effect of concept mapping instructional strategy and gender on secondary school students achievement in difficult physics concepts in Yola, Nigeria” by ugwumba (2018), “ effect of Novak colourful concept map with digital teaching materials on students’ academic achievement in Taiwan, China” by Chiou, Lee and Lio (2012), “the effect of concept mapping strategy as a graphical tool in writing achievement among EPL learners in Danesh Gostar language academy” by Shakoori, Kadivar and Sarami (2017), “the effect of concept mapping instructional strategy on Biology achievement of secondary school slow learners in Lagos, Nigeria” by Udeani and Okafor (2012), “concept mapping as a study skill: effects on students achievement in Biology in Delta state, Nigeria” by Patrick (2011). No study has investigated the effect of concept mapping instructional strategy accompanied with discussion web on students’ academic achievement in the concepts of Genetics in Ghana and the African continent at large. In order to address this gap in the literature, this study investigated the effect of concept mapping instructional strategy on students’ academic achievement in the concept of Genetics at Navrongo Senior High School in the Kassena Nankana Municipality of the Upper Region of Ghana.

3.0 METHODOLOGY

3.1 Research Design

This study adopted a pretest, posttest non-equivalent control group quasi-experimental design. This is because there was non-random sampling of students into groups. Navrongo Senior High School classes exist as intact groups and the school authorities and Ghana Education Service kicked against the dissolution and reconstitution of classes for research activities due to the outbreak of the novel Coronavirus popularly called Covid-19 which spread at a faster rate through contact. The school authorities and the Head of Science Department also kicked against the dismantle of classes and reconstitution for the purpose of research since it has the tendency of affecting the academic calendar and time table of the school. This design made use of two groups, control group (X_1) and experimental group (X_2). The groups were similar in academic achievement before treatment was administered to them. The experimental group was taught using Concept Mapping Instructional Strategy Accompanied with Discussion Web and the control group was also taught using Conventional Method of Teaching. The layout for the study is as follows:

Control Group X_1 ; O_1 X_1 O_2

Experimental Group X_2 ; O_3 X_2 O_4

Where; O_1, O_3 ; Pretest Achievement of students in the control and experimental groups;

O_2, O_4 ; Posttest Achievement of students in the control and experimental groups;

X_1 represents Conventional Teaching Method; and

X_2 , the Concept Mapping Instructional Strategy Accompanied by Discussion Web

3.2 Population and Sample

The study was conducted at Navrongo Senior High School in the Kassena Nankana Municipality in the Upper East Region of Ghana. The population for the study included all Form Three General Science programme students of Gold and Green tracks. Purposive sampling technique was used to select two intact classes for the study, one class from Form Three Gold Track science classes and another class from Form Three Green Track science classes. The two classes were randomly assigned into an experimental group class and control group class. The sample size for the study was 80, comprised of 23 males and 20 females of the Green Track class, assigned as the experimental group. Another 24 males and 13 females of the Gold Track class served as control group.

3.3 Data Collection Instruments

The instruments used for data collection were pretest and posttest which were developed by the teachers/researchers from the content that was covered in the study. The data were collected by the researchers before and after the intervention for a period of five weeks. The pretest, Genetics Understanding Test (GUT) was given to both groups before the treatment. The control group was taught using conventional teaching method and the experimental group was also taught using concept mapping instructional strategy accompanied with discussion web. The control and experimental groups were taught by one of the researchers. All lesson plans were prepared on the aspects of genetics using Ghana Education Service Teaching Syllabus for Biology. The aspects include: Terminologies used in Genetics; Chromosomes; Concept of Inheritance; Mendel's First and Second Law of Inheritance; Sex linkage and determination; Blood groups in man; Variation and Evolution. After the treatment, posttest, Genetics Achievement Test (GAT) was administered to both control and experimental group to determine the effectiveness of the treatment.

The pretest and posttest were made up of thirty test items each. Each test was divided into two section; A and B. Section A was made up of twenty multiple choice questions. Each multiple choice item had three distractors that reflected on students' misconceptions in genetics and one key. Section B was made up of ten short answers type questions. The pretest which was given to the participants before the intervention was different from the posttest.

The instruments for data collection were given to my mentor, a Biologist and senior lecturer at the University of Education, Winneba and three of my colleagues who are West African Examination Council Biology Examiners to help establish the content and face validity. The test items were piloted and the reliability of the items were determined using test-retest reliability coefficient. The reliability coefficient was found to be 0.70 and 0.73 for the pretest and posttest respectively. The data collected from the students' scores were analysed using descriptive statistics (mean and

standard deviation) and inferential statistics (independent student t-test) to test the null hypotheses at the significant level of 0.05, using Microsoft Excel 2016.

4.0 FINDINGS AND PRESENTATION

The data collected from the students' scores were analysed using descriptive statistics of mean, standard deviation and inferential statistic of t-test.

4.1 Research Question 1. What is the difference between the pretest mean scores of student in the experimental group and control group?

Table 1: T-test summary of pretest scores of students in the control and experimental groups

Group	N	Mean	SD	df	t-value	p-value	Remarks
Control	37	18.96	2.50	78	1.05	0.30	Not Significant
Experimental	43	18.37	2.43				

Source: Field data, 2021

Significant level = 0.05

Table 1 is a summary of the pretest mean scores of participants in the control and the experimental groups. The pretest mean score of students in the control group was similar to their counterparts in the experimental group. The pretest mean score of the control group was 18.96 with a standard deviation of 2.50. Also, the pretest mean score of the experimental group was 18.37 with a standard deviation of 2.43. To see if there was a significant difference between the pretest mean scores of the two groups, a null hypothesis was formulated.

4.1.1 Analysis of Research Hypothesis One

Research hypothesis 1: There is no significant difference between the pretest mean scores of students in the experimental and control groups.

From table 1, the t-value and p-value are; $t = 1.05$ and $p = 0.30$. the p-value is greater than 0.05. This indicated that there was statistically no significant difference between the pretest mean scores of the students in the experimental group and their counterparts in the control group. In the light of this result, it was hard to reject the null hypothesis. This proved that the two groups selected for the study were similar since there was no difference in their academic achievement before the intervention.

4.2 Research Question 2. What is the difference between the posttest mean scores of the experimental and control groups?

Table 2: T-test summary of posttest scores of students in the experimental and control groups

Group	N	Mean	SD	df	t-value	P-value	Remarks
Experimental	43	37.74	4.08	78	8.07	0.000	Significant
Control	37	31.21	3.15				

Source: Field data, 2020

Significant level = 0.05

Table 2 is a summary of the posttest results of students in the experimental and control groups. From table 2, the posttest mean score of students in the experimental group was 37.74 with a standard deviation of 4.08 while the posttest mean score of students in the control group was 31.21 with a standard deviation of 3.15. The mean difference between the group was 6.53. This proved that the academic achievement of students in the experimental group was far better than their cohorts in the control group. A null hypothesis was formulated to test for significant difference between the mean scores.

4.2.1 Analysis of Research Hypothesis Two

Research Hypothesis 2: There is no significant difference between the posttest mean scores of students in the experimental and control groups.

From table 2, the t-value and p-value are; $t = 8.07$ and $p = 0.000$. The p-value, $0.000 < 0.05$. This proved that the mean score of students in the experimental group differed significantly from their cohorts in the control group. In the light of this result, the null hypothesis was rejected. This indicated that there was statistically significant difference between the posttest mean score of students in the experimental group and their counterparts in the control group. This also showed that the treatment given to the experimental group was very effective and resulted in the difference in academic achievement of students in the experimental and control groups.

4.3 Research Question 3. What are the differences between the pretest and posttest mean scores of male and female students in the experimental and control groups?

Table 3a: T-test summary of the pretest of male and female students in the experimental group

Gender	N	Mean	SD	df	t-value	p-value	Remarks
Male	23	18.35	2.59	41	0.08	0.94	Not Significant
Female	20	18.40	2.33				

Source: Field data, 2021

Significant level = 0.05

Table 3a is a summary of the results of the pretest of the male and female students in the experimental group. From table 3a, the pretest mean score of the male students in the experiment group is 18.35 with a standard deviation of 2.59 while the female students had a mean score of 18.40 with a standard deviation of 2.33. The difference between the mean scores was 0.05. A null hypothesis was formulated to test if there was a significant difference between the mean scores.

4.3.1 Analysis of Research Hypothesis 3a

Research Hypothesis 3a: There is no significant difference between the pretest mean scores of the male and female students in the experimental group.

From table 3a, the t-value was 0.08 and p-value was 0.94. The p-value was greater than 0.05. In the light of this result, the null hypothesis was accepted. The result of the pretest proved that there was no statistically significant difference between the pretest means score of male and

female students in the experimental group. This is an indication that both male and female students in the experimental group were similar in academic achievement.

Table 3b: T-test summary of the posttest of male and female students in the experimental group

Gender	N	Mean	SD	df	t-value.	P-value	Remarks
Male	23	36.0	4.03	41	1.68	0.11	Not Significant
Female	20	38.70	3.15				

Source: Field data, 2020
 Significant level = 0.05

Table 3b is a t-test summary of the results of the posttest of male and female students in the experimental group. From Table 3b, the posttest mean score of the male students in the experimental group was 36.0 with a standard deviation of 4.03. Also, the female students in the experimental group had a mean of 38.70 with a deviation of 3.15. The mean difference between the two groups was 0.70. A null hypothesis was used to determine if there was a significant difference between the posttest mean scores.

4.3.2 Analysis of Research Hypothesis 3b

Hypothesis 3b. There is no significant difference between the posttest mean scores of the male and female students in the experimental group.

From table 3b, the t-value was 1.68 and the p-value was 0.11. the p-value is greater than 0.05. Based on the result, the null hypothesis was accepted. This proved that there was statistically no significant difference between the posttest mean scores of the male and female students in the experimental group. This showed that the intervention given to the experimental group was effective for both male and female students since there was no difference in their academic achievement.

5.0 DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

The purpose of the study was to explore the effect of concept mapping instructional strategy accompanied by discussion web on students' academic achievement in the concept of genetics. There was statistically no significant difference between the pretest mean scores of the control and experimental group. This proved that the two intact classes used for the study were similar in academic achievement in the concept of genetics before the intervention. This finding agrees with previous study by Woldeamanuel *et al.* (2020) who investigated the effectiveness of concept mapping based teaching method on grade eight students' conceptual understanding of photosynthesis at Ekwet Fana primary school, Bahir, Ethiopia and revealed that there was statistically no significant difference between the pretest mean scores of the experimental and control groups. This finding also confirms the finding of Awofala (2011) who explored the effect of concept mapping on students' achievement in mathematics and indicated that there was no significant difference between the pretest mean scores of the experimental and control groups.

Also, there was a statistically significant difference between the posttest mean scores of students in the experimental group and their cohorts in the control group. Students who were taught using concept mapping instructional strategy accompanied by discussion web performed significantly higher than their cohorts who were taught through conventional teaching method. This proved that the treatment was very effective and hence resulted in high achievement of students in the experimental group. Similar finding was made by Ugwumba (2018) who investigated the effect of concept mapping instructional strategy on secondary school students' achievement in difficult physics concepts in Yola, Nigeria and confirmed that students who were taught using concept mapping instructional strategy performed significantly higher than their counterparts in the control group. The finding also collaborates the finding of Cheema and Mirza (2013) who explored the effect of concept mapping instructional strategy on students' academic achievement in general science and showed that students who were exposed to concept mapping instructional strategy performed significantly higher than their cohorts who were taught using traditional teaching method. The study further agrees with the finding of Udeani and Okafor (2012) who studied the effect of concept mapping instructional strategy on Biology achievement of Senior Secondary School slow learners' and confirmed that the experimental group students who were taught using concept mapping instructional strategy performed significantly higher than the control group students who were taught using conventional teaching method. Furthermore, there was statistically no significant difference between the pretest mean scores of the male and female students in the experimental group. This is a clear indication that both male and female students were homogenous in academic achievement in the concept of genetics before the treatment.

Finally, there was statistically no significant difference between the posttest mean scores of the male and female students in the experimental group. This finding confirms the finding of Joel and Kamji (2016) who researched on the efficacy of concept mapping instructional strategy in remedying students' problem solving difficulties in stoichiometry and showed that there was no statistically significant difference between the posttest mean scores of male and female students taught using concept mapping instructional strategy. This finding also agrees with the finding of Githae *et al.* (2015) who conducted a study on the effect of collaborative concept mapping teaching method approach on secondary school students achievement in Biology in Nakuru, North Sub-County, Kenya and revealed that there was statistically no significant difference between the posttest mean scores of the male and female students exposed to concept mapping teaching method. The finding of this study disagreed with Udeani and Okafor (2012) who investigated the effect of concept mapping instructional strategy on students' achievement in Biology and confirmed that the female students in the concept mapping group performed significantly higher than the male students.

5.2 Conclusion

This study investigated the effect of concept mapping instructional strategy accompanied by discussion web on students' academic achievement in the concept of genetics at Navrongo Senior High School in the Kassena Nankana Municipality in the Upper East Region of Ghana. The results of the study proved that concept mapping instructional approach accompanied by discussion web is very effective in improving the academic achievement of students' in the concept of genetics since students in the experimental group performed significantly higher than their cohorts in the

control group. It is also established that concept mapping instructional approach improved the academic achievement of both male and female equally since there was no statistically significant difference between male and female students in the concept mapping instructional strategy group. In summary, concept mapping instructional strategy accompanied by discussion web significantly improved the understanding and academic achievement of learners in the concept of genetics.

5.3 Recommendations/ Contribution to Practice, Theory and Policy

From the results of the study, the following recommendation were put forward by the researchers:

- i. Biology teachers should be encouraged to use concept mapping instructional approach as an instructional method when teaching genetics in order to improve the academic achievement of students.
- ii. The Government, Ghana Education Service (GES) and Ministry of Education should organize workshops, seminars and conferences for Biology and science teachers in general on the need to use current instructional methods that are capable of enhancing the academic performance of learners.
- iii. Concept mapping instructional strategy accompanied by discussion web moves us towards constructivist approach of teaching and learning process. Curriculum developers should incorporate this instructional method into the new curriculum to supplement the existing teaching methods.
- iv. The Government, Ghana Education Service and Ministry of Education should establish professional development fund for teachers to enable them upgrade professionally and also improve on their teaching styles since most teacher are not abreast with the current or modern methods of teaching.

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