Effects of Concept Mapping Strategy on Students' Perception and Performance in Photosynthesis and Cellular Respiration

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ABSTRACT

The purpose of this research was to examine how the use of concept mapping strategy affected the comprehension of photosynthesis and cellular respiration among second-year students studying elective biology at Akim Swedru Senior High School. A total of 105 students participated in the study, which spanned six weeks. Pre-test and post-tests were administered using a biology test developed by the teacher. The results indicated significant differences between the experimental group, taught using concept maps, and the control group, taught using traditional methods. This suggests that concept maps assist students in understanding the subject matter, identifying key concepts, and establishing connections between different concepts. Additionally, the study uncovered positive perceptions among students regarding the effectiveness of concept maps as a teaching approach in Biology. Consequently, it is recommended that biology teachers in other Senior High Schools incorporate concept mapping as a teaching method. Furthermore, it is suggested that this study be replicated in different regions for further validation.

Keywords: Concept maps, biology, photosynthesis, performance, cellular respiration, students, senior high school,

INTRODUCTION

Effective instruction often incorporates learning theories, and there are concerns about the effectiveness of available educational software and the importance of integrating learning theories into teaching practices. One influential cognitive theory is Ausubel's learning theory, which emphasizes meaningful learning (Ausubel, 1968). Concept maps, proposed by Joseph Novak as an educational aid, are based on constructivist learning theory, where learners actively build their knowledge (Richardson, 2005; Basso & Margarita, 2004). Ausubel suggests using advanced organizers, which provide a brief overview of new material before a lesson to prepare students for better understanding (Reece & Walker, 2003). The modern view of scientific knowledge, influenced by new philosophers of science like Kuhn, rejects the traditional cumulative approach in favor of conceptual change, as seen in Mucherah's works (Mucherah, 2008). Concept mapping draws from the cognitive perspectives of psychologists with constructivist views and the new philosophers of science (Basso & Margarita, 2004). However, it is Ausubel's cognitive assimilation theory from 1968 that serves as the theoretical foundation for concept mapping.

Concept mapping has become increasingly popular in science education, thanks to recent advancements in cognitive science and the new philosophy of science (Bakouli & Jimoyiannis, 2018). This instructional tool aids learners in retaining concepts for longer periods and using them more effectively. Concept maps are visual representations that demonstrate the relationships between various concepts or situations by linking a central concept to others, enhancing the learners' comprehension of the central idea (Juall & Moyet, 2005). The structure of concept maps resembles pyramids seen from above, organized hierarchically, with the most inclusive concept at the top and less inclusive ones below (Ahlberg & Vukko, 2004). These graphical tools,

as described by Novak and Canas (2006), help organize and represent knowledge, allowing learners to integrate new concepts with their existing understanding. Concept maps also foster idea generation and creativity while providing a tangible visual image of the studied concepts, facilitating easy focus and revision. Throughout the formulation process, learners develop a concrete and precise understanding of the meanings and interrelations of concepts, making learning an active, rather than a passive, process.

Over time, Ghanaian students' performance in biology has shown a steady decline, especially in public examinations like the West African Secondary School Certificate Examination (Chief Examiners' Report, 2018). This decline may be attributed to the introduction of more difficult concepts and instructional methods used in biology education. The Chief Examiner's Reports for the West African Secondary Students Certificate Examination (WASSCE) in 2012, 2013, and 2018 explicitly state this concern. Students themselves perceive biology as a subject that requires extensive reading, making it challenging for them to learn (Mucherah, 2008). Moreover, inadequate and subpar practical sessions in the laboratory, as pointed out by Anthony-Krueger (2007), may also contribute to the students' poor performance in biology.

To address these issues, there is a growing interest in exploring students' perceptions of the concept mapping approach to biology instruction and evaluating the potential effects of using concept maps as an instructional tool to enhance students' understanding of topics like photosynthesis and cellular respiration.

Objectives of the Study

1. To assess the effects of concept mapping on the performance of students in photosynthesis and cellular respiration
2. To explore students' perceptions of concept mapping approach for biology lessons

Hypothesis

H_0: There is no statistical significant difference between achievements of students taught photosynthesis and cellular respiration with concept mapping and those taught with traditional method.

LITERATURE REVIEW

The Etymology and Conceptualisation of Concept Maps

Concept mapping, as defined by Novak (2010), is the creation of a network of interconnected concepts that collectively address a focus question, describe a broader topic, or establish relationships between specific concepts. This metacognitive tool is applicable to any discipline and level of education, benefiting both students and teachers in enhancing their understanding of meaningful knowledge (Edmonson, 2000). Concept maps have gained popularity in classrooms, particularly in science education, where they serve as valuable tools for comprehension and development of concepts by illustrating important concepts and their relationships within a knowledge domain (Novak, 2010). These maps consist of enclosed circles or boxes representing concepts, connected by lines or labeled arrows indicating the relationships between them. The hierarchical structure of a concept map depends on the specific context of the knowledge being applied (Novak & Canas, 2006). Concept mapping aids learners in organizing their cognitive frameworks into integrated patterns, serving as both a meta-knowledge and meta-learning strategy (Kinchin, 2005). Research has shown that concept mapping can improve meaningful learning and encourage independent learning (Kinchin, 2003; Mintzes et al., 2001). Concepts on the map may appear only once but can be linked to multiple other concepts, allowing learners to draw connections and understand relationships between different concepts (Van Drie & Van Boxtel, 2003). A significant strength of concept mapping is its flexibility, as there is no single correct way to create one, allowing for customization based on the specific needs of learners (Javonillo & Martin-Dunlop, 2019). Modifications like color-coding, grouping concepts, or using various shapes can assist students with special needs. Furthermore, concept mapping can be

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adapted for collaborative settings, facilitating discussions and even turned into interactive games using three-dimensional map structures (Van Drie & Van Boxtel, 2003).

Students' Perceptions of Concept Mapping

The combined findings of several studies suggest that students generally view concept mapping as a valuable and effective learning tool. One study by Christandhi (2017) focused on the use of concept mapping for learning English vocabulary. The results, gathered through a quantitative questionnaire, revealed that students responded positively to concept mapping, finding it easier, clearer, and more engaging compared to other methods. Moreover, concept mapping was found to enhance brainstorming skills and reduce the need for extensive note-taking. Similarly, a study by Latif (2018) explored nursing students' perceptions of concept mapping in teaching and learning. While the specific details of their positive-medium perception were not provided, it indicates that students recognized the value of using concept maps in their studies. Another related study by Nuuyoma and Fillipus (2020) investigated nursing students' experiences and perceptions of concept mapping in the context of human physiology. The findings showed that nursing students had positive experiences and perceptions of concept mapping. However, they also noted that concept mapping was perceived as time-consuming and requiring substantial learning resources. Additionally, Rahnama and Mardani-Hamooleh (2017) discovered that concept mapping assists students in developing critical thinking and judgment skills, suggesting a positive link between concept mapping and the enhancement of these cognitive abilities.

Bunting et al. (2006) conducted a study with first-year tertiary biology students in New Zealand, employing a concept map approach. The students were divided into three groups: an experimental group exposed to concept mapping in their tutorial class, a second group without concept mapping tutorials, and a third group with no tutorials at all. After the intervention, students in the experimental group provided their feedback on the concept map approach.The students found concept mapping to be a helpful strategy for understanding the relationships between concepts and conceptual themes. They reported that concept mapping tutorials helped them grasp lecture content more clearly, as they could explicitly identify and comprehend the connections between concepts. Many students appreciated the opportunity to construct their own concept maps individually or in small groups. Additionally, they acknowledged that concept mapping helped them identify areas where they had weaker understanding. On the other hand, Scagnelli (2010) conducted a study with third-grade science students and found that some of them enjoyed constructing concept maps, finding the process enjoyable. However, some students had issues with the concept mapping strategy. Similar to the findings of Nuuyoma & Fillipus (2020), Bunting et al. (2006) also reported that some students perceived concept map construction as time-consuming. Some students felt that concept mapping was not suitable for every aspect of a topic, as certain areas required charts, diagrams, and tables. Furthermore, students found concept mapping to be different from the traditional teaching approach, which made them uncomfortable with this new method of learning biology. For those students accustomed to rote learning, concept mapping was not favorable, as it did not align with assessments that focused on memorization.

Based on the findings, it can be concluded that concept mapping is seen as a valuable method that improves comprehension, encourages active participation, and fosters critical thinking skills. The overall positive responses suggest that concept mapping is viewed as an effective and beneficial technique across different academic disciplines. However, some students may also perceive it as time-consuming and needing additional resources. Despite this, the general consensus remains favorable towards concept mapping as an impactful learning approach.

Effect of Concept Mapping on Students' Achievement in Biology

Concept maps have been widely recognized as effective tools in facilitating meaningful learning. Several studies have shown positive results regarding their use in various educational contexts. Bunting et al. (2006)

observed that students who studied biology using concept mapping achieved significantly higher marks compared to those who followed traditional methods. However, for test items that did not require sophisticated conceptual organization, there was no notable difference between the concept mapping group and the non-concept mapping group. Akpinar and Ergin (2008) taught students about animal cells using interactive computer animation instruction accompanied by concept maps from both teachers and students, alongside traditional teaching methods. They found a statistically significant difference between the concept map group and the traditional method group, favoring the concept map group. Asan (2007) conducted a study among fifth-grade science students in Turkey, using computer-based concept maps through "Inspiration" for the experimental group and traditional teaching methods for the control group. The experimental group achieved significantly higher scores than the control group. Ampiah and Quartey (2003) conducted a study with SSS 2 elective chemistry students in a girls' school in Ghana. They noticed that the experimental group, using concept mapping, performed better than the control group in understanding, explanation, and application questions, but there was little difference in questions that demanded factual recall. Both groups, however, performed poorly in test items requiring problem-solving skills. Similarly, Boujaoude and Attieh (2008) found a significant difference at the knowledge level, with the experimental group scoring higher than the control group. However, they found no significant difference at the comprehension and application-and-above level. Concept mapping was particularly helpful for students who scored below average, as it improved their performance on higher cognitive level questions.

Chei-Chang (2008) conducted a study in an advanced accounting course and found that implementing a concept mapping strategy significantly improved students' learning achievement. Students expressed high levels of satisfaction with concept mapping, noting that it helped them understand, integrate, and clarify concepts while increasing their interest in learning. In a quasi-experimental research study involving 7th-grade students in general science, Cheema and Mirza (2013) compared the academic performance of students taught through concept mapping with those taught using traditional methods. Both male and female students taught through concept mapping achieved better academic performance compared to those taught through traditional methods. Appaw, Owusu, Frimpong, and Adjibolosoo (2021) conducted a related study comparing the effectiveness of concept mapping, based on constructivist theory, with traditional teaching methods in the context of biology education in Senior High Schools. The findings revealed that students instructed with concept mapping outperformed those taught using traditional methods, recommending the widespread use of concept mapping in biology classes at the Senior High School level. Likewise, Luchembe, Chinyama, and Jumbe (2014) investigated the effectiveness of concept mapping as a teaching strategy for undergraduate students taking an introductory physics course in Zambia. The study compared concept mapping with the use of tutorial sheets in teaching circular and rotational motion. The results showed that concept mapping was more effective in enhancing student learning outcomes compared to the tutorial sheet strategy. However, Singh and Moono (2015) conducted a study in Zambia to assess the effectiveness of using a combination of concept maps and traditional teaching methods in teaching selected topics in chemistry. Surprisingly, the findings indicated no significant difference in the performance of students in the control and experimental groups. Nevertheless, the study emphasized that the best scores were achieved when students were taught using both concept map teaching strategies and traditional methods.

Overall, these studies suggest that concept mapping can be a valuable teaching strategy for enhancing students' learning outcomes and understanding in various subjects. However, the effectiveness may vary depending on the specific subject area, instructional context, and the combination of teaching methods used.

METHODOLOGY

Research Design and Approach

A quasi experimental design was adopted in this study. The study succinctly succumbed to the quantitative

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approach to research inquiry. This suggests that data obtained were purely numeric and analyses were entirely non-interpretive.

Research Instrument

For the purposes of amassing a considerable amount of relevant data, tests (pre-test and post-test) and questionnaires were adopted as the major data collection tools. Two tests were used to measure students' achievement in biology. One of the tests (pre-test) measured students' prior-knowledge in topics related to the ones covered during the study. The second test measured students' achievement at the conclusion of the study. The achievement test was developed from the topic in the science syllabus for SHS whereas other items were also selected from past WASSCE questions to determine the effect of using the concept mapping. The instrument consisted of 5 essay type questions at a 2:2:1 ratio vis-à-vis the science curriculum profile dimension. The questions were worth four points each and the tests were rated on a 20-point scale.

The use of questionnaire was to measure objectively the effectiveness of the concept mapping integration in instructional process of biology. The researcher, with the help of research assistants, read out the question items to the respondents and explained them accordingly. The instrument had two sections (Section A and Section B) but in relation to the latter section, respondents were to indicate their responses using a five-point Likert Scale (SA, A, Neutral, Disagree and Strongly Disagree).

Population and Sample Size

The target population for this research was all students studying science in Akim Swedru Senior High School in the Eastern Region of Ghana. The accessible population was all second year students studying elective biology whose population was 105. These students were selected for the research because they have been exposed to at least one year of science teaching and learning at the senior high school. Three sampling strategies were employed in the selection process namely convenient, purposive and random sampling techniques. Convenience sampling was used to choose all the one hundred and five (105) students. This procedure was involved in determining the experimental school and the year groups (Form 2 Biology classes). However, through purposive sampling technique, the sampled were further assigned to two discrete groupings (controlled and experimental groups) based on the outcome of the pre-test results. In all, two intact Form (SHS) 2 biology classes were used. These were exclusively General Science class forming the control group and the Home Economic class experimental group. Nevertheless, the final sample size was obtained through randomization. The systematic random sampling was used to choose fifty-one (51) respondents for the experiment. This consisted of twenty (20) females and thirty-one (31) males.

Validity and Reliability of the Instrument

The content validity of the instruments was determined through experts and subject specialists' judgment and advice. Again, both pre and post tests were developed based on the SHS biology syllabus, text books, and modified questions of the West African Examination Council. To ensure the consistency of the results on the other hand, pilot testing was done at Achiase Senior High to check the reliability of the study. The school took a pretest and also a posttest after a week of treatment. The students that received instruction through concept mapping approach were given questionnaire to respond on their perceptions towards concept mapping after they have taken the posttest. The inter-rater reliability of the biology achievement pretest was 0.78 and 0.79 for the posttest. Cronbach Alpha coefficient of reliability of the questionnaire was 0.90.

Intervention/Data Collection

This research was carried out at Akim Swedru Senior High in the Birim South District of the Eastern region, Ghana over a period of six weeks with the Science and Home Economics classes which met three times per week for ninety minutes. Intact classes were used and the materials that were covered were outlined in the biology syllabus. The study pre-intervention test was administered to all one hundred and five second year biology students. The results of the pre-intervention test were used to classify the Home Economics class as the experimental group since they scored below fifty percent while the science class was used as the control group because they scored above sixty percent. Both classes were taught photosynthesis and cellular respiration as outlined in the biology syllabus. In the control class, the students were taught four lessons on photosynthesis using the traditional method lasting ninety minutes each. Subsequently, four lessons on cellular respiration were taught which also lasted ninety minutes per lesson. Here the researcher did most of the talking while the students did the listening Researcher occasionally demonstrates a process for students observe, engage students in brief discussion and questioning and often use illustration from diagrams, charts and relia.

In the experimental class, the students were given tuition on how to create concept maps in five lessons on photosynthesis which lasted for ninety minutes each. This was also followed by another four lessons on cellular respiration using concept mapping as a mode of instructions. Shortly thereafter, the students were placed into groups of five and given a short activity to construct micro-concept maps on the content of each lesson. These concept maps were scored using the researcher's scoring rubric and returned the next day to the students. The experimental students were asked to construct detailed samples of concept maps on both photosynthesis and cellular respiration. At the end of the treatment period, both the experimental and control groups took the post-test at the same time. The student's questionnaire items were administered to the experimental students after the post-treatment test for analysis.

Data Analysis

The statistical program SPSS 20.0 was used for analysis of data. The scores from pre-test and post-test in the achievement tests were subjected to descriptive and inferential statistics. Descriptive statistics included mean, standard deviation and percentages etc. Inferential Statistics used was t-test at testing of the statistical significance at 0.5 alpha levels were employed for the analysis of data. When the P values from the results of these statistical tools are above 0.5, then there is no significant difference, but if the P values are less than 0.5, then there is significant difference

RESULTS AND DISCUSSION

Objective 1: Effects of concept mapping on students' performance in photosynthesis and cellular respiration

Results presented in Tables 2 and 3 provide answers to research objective one. Paired sample t-test was performed to assess the effect of the intervention (concept maps) on the experimental group. The results generated using SPSS version 20 are presented Table 2 and Table 3.

Table 2: Means and standard deviations for both control and experiment groups before and after the treatment

Group	Variable	N	Mean	SD	p
Experimental	Pre – test	51	6.24	1.577	0.000

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Group	Variable	N	Mean	SD	p
Experimental	Pre – test	51	6.24	1.577	0.000
	Post – test	51	15.16	1.953	
Control	Pre – test	54	6.47	1.554	0.000
	Post – test	54	14.22	1.265	

Significant P<0.05

Table 2 presents a statistically significant disparity in the pre-test and post-test scores of the two groups. The mean scores for the post-test in the experimental group were found to be considerably higher compared to the mean scores for the pre-test. Additionally, it was observed that the mean of the control group in the post-test exhibited a statistically significant increase compared to the pre-test. The obtained p-values provide evidence to support the presence of a statistically significant distinction between the pre-test and post-test scores in both the experimental and control groups ($p < 0.05$). This implies that the intervention implemented in the experimental group had a significant influence on the academic achievement of the students. The findings shown in Table 2 demonstrate that both the use of concept mapping and the traditional teaching methods yielded noteworthy outcomes in terms of students' academic achievement in the subjects of photosynthesis and cellular respiration.

The researcher provided instructions to both groups. In contrast, the control group was provided with training afterwards to the experimental group. As is customary for educators seeking to enhance subsequent instructional sessions, the challenges encountered in the experimental group were rectified prior to providing instructions to the control group. This variable may have contributed to the notable enhancement in the average scores of the control group.

Research Hypothesis

H_0: There is no statistical significant difference between achievements of students taught photosynthesis and cellular respiration with concept mapping and those taught with traditional method.

In order to examine the disparity in post-test results between the experimental and control groups, a comparison was conducted by utilising an independent sample t-test to analyse the mean scores. The outcomes of the independent sample t-test conducted on the post-test data for both the experimental and control groups are displayed in Table 3.

Table 3: Means and standard deviations of experimental and control groups after the treatment.

Group	N	Mean	SD	t	p
Experimental	51	15.61	1.953	4.370	.000
Control	54	14.22	1.265	–	–

Significant at P<0.05

According to the data shown in Table 3, a notable disparity was seen in the average post-test scores between the experimental and control groups. Therefore, the null hypothesis is deemed to be rejected. According to the findings shown in Table 3, students who were exposed to concept mapping had superior academic performance compared to their peers who were exposed to the conventional traditional mode of teaching. The observed difference in mean scores between the two groups was 1.39. The group that utilised concept mapping demonstrated statistically significant higher scores compared to the group that employed the

traditional technique. A significant effect size is indicated by a value of 0.71. According to the research conducted by Green, Salkind, and Akey (1997) as well as Cohen (1988), it has been established that an effect size of 0.20 is considered to be extremely little, while an effect size of 0.50 is classified as moderate, and an effect size of 0.80 is categorised as big. In their study, Bunting et al (2006) found that students who participated in tutorials utilising concept mapping as an educational technique demonstrated notably higher results compared to those who attended traditional classes or did not attend any tutorials. In previous studies conducted by Asan (2007) and Akpinar & Ergin (2008), it was shown that students who were instructed using concept maps had considerably greater academic achievement compared to those who were taught using standard instructional methods.

Research Objective 2: To explore students' perceptions of concept mapping approach for biology lessons at Akim Swedru Senior High School

Table 4: Students' perceptions of concept mapping approach for biology lesson

S/N	Items	Agree f (%)	Undecided f (%)	Disagree f (%)
1	Concept mapping makes biology class interesting	48(94.12)	1(1.96)	2(3.92)
2	Concept map links the various concepts together	40(78.43)	1(1.96)	10(19.61)
3	Students are much involved in concept mapping	51(100)	0(0)	0(0)
4	Concept maps summarize the topic	41(80.39)	4(7.84)	6(11.77)
5	Concept maps bring out the meaning of the topic better	46(90.20)	1(1.96)	4(7.84)
6	Concept maps stimulates me to learn biology	48(94.12)	0(0)	3(5.88)
7	Concept maps demands a lot of thinking	30(58.82)	1(1.96)	20(39.22)
8	Concept map assignments help me prepare for my exams	39(76.47)	9(17.65)	3(5.88)
9	Concept maps provide me with better understanding of complex topics	37(72.55)	1(1.96)	13(25.49)
10	Concept maps facilitate making interconnections among (sub) chapters	48(94.12)	0(0)	3(5.88)
11	Concept mapping can be used in learning other subjects	48(94.12)	1(1.96)	2(3.92)
12	Concept maps helps me identify the relations amongst the concepts	48(94.12)	0(0)	3(5.88)
13	Constructing concept maps is not time-consuming	17(33.33)	4(7.84)	30(58.83)

n = 51

DISCUSSION

The results show that majority of the students exposed to concept mapping had their reservations about the approach. They seem to have observed and endorsed the promising sides of the technique as against the dark sides. The analyses indicate that a considerable number of respondents were in favour of the positive indicators of concept maps. A great section of respondents (students) 41(80.39%) seems to be in consensus that concept maps as an instructional strategy to biology teaching and learning summarise biology topics for

them. Others 48(94.12%) also asserted that the approach appears to have the capacity of making Biology class interesting. Relative to this, it can be realized that the multifaceted nature of concept maps was also acknowledged when the majority 48(94.12%) claimed that the approach can be used for the teaching of other courses. In the same way, a convincing proportion 40(78.43%) of respondents responded that concept maps link various concepts in biology such as photosynthesis and cellular respiration. Further, all the respondents held the view that students are much involved in concept maps. To them, with concept maps, students are active rather than passive ingredients in the learning process. In relation to whether concept map assignments help students to prepare for exam, it was realized that only a handful 3(5.88%) opposed to this indicator suggesting that the approach possesses the ability of equipping students to confront assessment activities and other related evaluative tasks. On the other hand, more than half of the students 30(58.83%) indicated that constructing concept maps is time-consuming.

The results of this study align with previous research indicating that students hold a favourable impression of concept mapping. This study aligns with other research undertaken by Latif (2018), Nuuyoma and Fillipus (2020), Scagnelli (2010), Bunting et al (2005), and Asan (2007), which similarly show that students who exhibited favourable attitudes and perceptions towards concept mapping attained higher scores on their post-tests. After completing the concept mapping lessons, the experimental group show a greater inclination towards perceiving concept mapping as a valuable tool for boosting the efficacy of learning. The majority of students conveyed their perspective that the utilisation of the concept mapping technique proved to be quite beneficial in facilitating the comprehension of photosynthesis and cellular respiration. Additionally, a majority of students expressed that the use of the concept mapping technique facilitated the mitigation of obstacles and enhanced their acquisition of knowledge in the field of biology. Regarding emotional acceptance, the experimental group had a greater inclination towards concept mapping, demonstrating a more positive attitude towards the use of the concept mapping technique. The vast majority of the students held the viewpoint that concept mapping had the potential to be a viable educational approach. The majority of students expressed a positive reception and a sense of contentment in implementing concept mapping as a pedagogical tool. The students comprising the concept mapping group also held the belief that the use of concept mapping could be readily extended to several other academic disciplines. The aforementioned viewpoints align with the effective applications of concept mapping in several fields, as demonstrated by Ahlberg et al. (2005), Chang et al. (2002), and Freeman & Jessup (2004). Harpaz et al. (2004) and Ritchie and Volkl (2000).

However, more than half of the students 30(58.83%) indicated that constructing concept maps is time-consuming. This finding is consistent with that of Nuuyoma and Fillipus (2020). Nuuyoma and Fillipus found that though nursing students had positive experiences and perceptions of concept mapping, they also perceived it as time-consuming and requiring significant learning resources. The result points out the importance and difficulty of preparing and training students for concept mapping tasks.

CONCLUSION

The findings of the research provide evidence in favour of employing concept mapping as an instructional approach to actively include students in the process of developing and modifying their own cognitive frameworks. Nonetheless, it is important to provide assistance to biology students and educators, regardless of their specific curriculum, in comprehending and actively employing concept mapping due to its potential advantages in the realm of scientific education. The study identified a significant educational significance of concept maps as a teaching tool in relation to students' grades. The method was shown to be beneficial in assisting the experimental group in enhancing their academic performance. In light of the findings, the study posits that the use of concept maps as a pedagogical approach does not only result in a significant improvement in students' academic performance. However, it does have the potential to guide students in novel learning encounters, therefore influencing their perspectives on the process of science education, particularly within the domain of Biology. Based on the findings of the study, it can be deduced that the use

of concept maps as an instructional tool for undergraduate students pursuing science-related majors may significantly enhance their comprehension of subject matter, concepts, and material within their respective fields of study.

RECOMMENDATIONS

The use of concept mapping as a teaching approach by Biology instructors at the Senior High School (SHS) level in the Birim South District, Ghana, is deemed worthwhile due to its shown success. The utilisation of the idea mapping approach should be promoted in numerous Biology classrooms as it affords students the ability to discern connections between concepts, effectively condenses and arranges their work, and facilitates logical and sequential organisation of their thoughts. It is important for science educators to acknowledge the necessity of extended training sessions and personalised feedback in order to afford learners the chance to proficiently acquire idea mapping skills.

A significant proportion of students (58.83%) reported that constructing concept maps is time-consuming, which could impact their willingness to engage with the approach. Addressing time constraints through effective instructional strategies or providing additional support and resources may help mitigate this challenge.

Suggestion for Further Studies

The research is conducted in a specific region (Birim South District, Ghana), which limits its applicability to other contexts or educational settings. In further studies, it is suggested that the study is replicated in diverse cultural and educational contexts and geographical locations with different student populations. This could enhance the generalizability of the findings. Comparing the effectiveness of concept mapping across different regions and student populations would enrich the understanding of its applicability and effectiveness in varied settings.

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