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Concept Mapping Teaching Strategy and the Academic Performance in Science of Senior High School Students Towards a Proposed Learning Action Cell

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ABSTRACT: This study explored the role of concept mapping in improving academic performance, engagement, motivation, and critical thinking and problem solving, particularly in learning complex topics like the evolution of Grade 11 students. Conducted in a real classroom environment, the research involved assessing students' academic performance before and after implementing concept mapping as a teaching strategy. The primary objective was to determine whether students' positive assessments of concept mapping, such as ability to enhance engagement, motivation, and critical thinking and problem solving, correlated to the measurable improvements in their learning outcomes. Through statistical analysis, the study found that concept mapping significantly improved students' performance, validating it as an effective instructional strategy with potential for wider educational use. The results also demonstrated that while students acknowledged the benefits of concept mapping for organizing and visualizing complex ideas, its direct impact on their post-test scores was not statistically significant. This suggested that academic performance might be influenced by multiple factors beyond engagement, motivation, critical thinking and problem solving. Given these findings, the study emphasized the need for further investigation into optimizing concept mapping for greater academic impact. It also recommended implementing the LAC training program on concept mapping.

KEYWORDS: concept mapping strategy, evolution, Grade 11 students, motivation, student engagement

I. INTRODUCTION

Filipino students' position in scientific education was alarming. Based on Organization for Economic Co-operation and Development (OECD) 2023, PISA 2022 Results (Volume I and II), 23% of students attained Level 2 or higher in science, demonstrating the ability to recognize correct explanations for scientific phenomena and identify valid conclusions in the Philippines. However, only 7% of students were top performers in science, proficient at Level 5 or 6, and could creatively apply their knowledge to various situations, including unfamiliar ones. This highlighted the need for more students to develop their science skills and abilities.

According to Barrientos (2015, as cited in Allawan, 2021), the findings in the Trends in Mathematics and Science Survey (TIMSS) which was carried out five years ago prior to his study were disappointing because the Philippines placed 42nd in science out of 45 countries examined. The findings from this survey provided valuable insights into factors influencing performance in the National Achievement Test (NAT). Research consistently linked poor teaching methods, approaches, and strategies to students' low academic performance across various subjects and educational levels. Ineffective instructional practices failed to engage students or address their diverse learning needs, resulting in diminished understanding and retention of key concepts. Gabel (2003, as cited in Akintola and Odewumi, 2021) highlighted this issue in the context of science education, arguing that the lecture method was particularly unsuitable for teaching sciences in high schools. He further stated that the lecture method often emphasized passive learning, where students were expected to absorb information without actively engaging with the material. This approach was inadequate for science education, which required hands-on exploration, critical thinking, and the ability to connect theoretical concepts with practical applications. By relying on lectures, teachers might miss opportunities to foster inquiry, experimentation, and collaborative problem-solving, all of which were essential for meaningful learning in science. To address this, teachers must adopt more interactive and student-centered approaches, such as inquiry-based learning, group discussions, and the use of visual tools like concept mapping. These strategies not only enhanced engagement but also promoted deeper understanding and retention of scientific principles.

As a biology teacher, the researcher consistently observed that many students struggle with understanding abstract and conceptually challenging topics, particularly in General Biology 2. Despite efforts to present the content clearly, it became evident that some students lacked the foundational knowledge necessary for deeper comprehension. Recognizing the importance of identifying these gaps early, the researcher conducted a diagnostic test to assess students' prior knowledge before beginning formal instruction as it highlighted gaps in students' knowledge or misconceptions that needed to be addressed during the course and helped teachers tailor their lessons and instructional strategies to address the specific needs of students, ensuring that teaching was focused on areas where students might struggle. The results revealed that the average scores on critical topics such as evolution, natural selection, and genetic variation were significantly low (48%, 60% and 55%, respectively), indicating that students struggled with understanding these abstract concepts. The low pretest results in General Biology 2 indicated a clear need for instructional strategies that helped students organize, connect, and apply complex biological concepts particularly on evolution. A pretest was conducted in the researcher's class before the formal instruction of General Biology 2 to evaluate students' baseline understanding and to identify misconceptions or knowledge gaps. The results of the pretest revealed notably low average scores in critical topics such as evolution (48%), natural selection (60%), and genetic variation (55%). These findings underscored students' difficulties in grasping abstract and complex biological concepts, signaling the need for more effective instructional strategies.

To address these learning challenges, the use of concept mapping was explored as a potential solution. Concept mapping provided a visual framework that helped students organize information, recognize relationships among concepts, and improve overall comprehension. By offering a structured way to connect prior knowledge with new information, this strategy held promise in enhancing student understanding, retention, and academic performance in topics such as evolution and other related areas in General Biology 2.

Teaching evolution presented unique challenges for teachers, as it was often regarded as a complex and sensitive topic. Panol, Caballes, Vasquez, and Valdez (2021) disclosed that teachers must adopt approaches that simplified abstract ideas, promoted critical thinking, and fostered respectful discussions to meet the diverse needs of students and achieve lesson objectives. They added that strategies like concept mapping could help students visualize relationships between key concepts, while inquiry-based learning could encourage exploration and understanding. Thus, the selection of appropriate instructional methods was crucial for overcoming these challenges and ensuring that students gained a clear, well-rounded understanding of evolution.

Joseph Novak first introduced concept maps in the 1970s, and since then, they had been thoroughly studied and improved. Lenski, Elsner and Groeschel (2022) stated that network-like diagrams called concept maps (CMs) were used to describe and organize knowledge as they provided a concise and graphic representation of the key ideas and connections among a subject.

Why use concept mapping in classroom? There were several applications for concept mapping. According to Sinha (2020), it gave students a visual road map of concepts, which had a lasting effect on them. Studies showed that students who were taught using the concept mapping approach were able to recall the concepts for longer than those who were taught using the lecture or traditional method. There were several uses for concept mapping. There were several uses for it. For example, for assessment purposes. Additionally, a concept map created by the student helped the teacher in identifying the student's misconceptions. Additionally, because concept mapping presented ideas in a clear and concise manner, students could utilize it as a fast revision tool.

Concept mapping, a graphical tool for organizing, representing, and eliciting knowledge, drew increasing interest and use in STEM (science, technology, and mathematics) fields as a successful teaching method to enhance students' conceptual comprehension. It had gained prominence as an effective educational tool, particularly in teaching complex scientific concepts like evolution. Recent studies highlighted its benefits in enhancing student understanding and engagement. A 2023 systematic review analyzed concept map-supported education from 1992 to 2020. From the review results, Chang, Hwang and Tu (2022) identified two main thematic clusters: knowledge construction in collaborative learning and learning design to improve achievement and motivation. In knowledge construction in collaborative learning, concept maps allowed students to build and visualize information together, which promoted collaborative learning. Numerous subjects, including science courses like biology, used this methodology. In learning design to improve achievement and motivation, concept maps were increasingly being used in digital game-based learning environments, suggesting a trend toward combining concept mapping with technology to enhance learning's interactivity and appeal.

The foundation of concept mapping lay in the constructivist learning theory, which posited that students actively constructed their understanding of the world by integrating new information with prior knowledge. Novak and Canas (2006, as cited in Akintola and Odewumi, 2021) emphasized that concept maps aligned with this approach by encouraging students to organize and represent their knowledge meaningfully. This active engagement not only deepened comprehension but also supported long-term retention and application of information, making concept maps a powerful tool for both individual learning and collaborative problem-solving. Concept maps became a valuable tool for promoting meaningful learning across various disciplines, including the sciences, education, government, and business. They served as a visual representation of knowledge, illustrating the relationships between concepts in a structured and interconnected way. This made them particularly effective for simplifying complex ideas, enhancing understanding, and facilitating collaborative knowledge-sharing among individuals and teams.

Concept mapping might be a valuable tool for science education, but there was a lack of research on its application in teaching evolution, particularly among Grade 11 students. Existing studies were often focused on general science or biology education but rarely on teaching evolution. Evolution involved abstract and interrelated concepts, making it challenging for students to grasp. There was insufficient empirical evidence linking concept mapping directly to measurable improvements in academic performance, particularly in senior high school settings. Most studies emphasized cognitive benefits without providing robust data on how it influenced test scores, retention, or knowledge application in evolution. Limited research was also available on how concept mapping could be systematically integrated into teaching evolution.

Thus, the aim of this study was to assess the effectiveness of the concept mapping strategy in teaching evolution and the relationship between respondents' level of assessment and post-test scores of Senior High School Students, particularly the Grade 11 students taking General Biology 2 in Sun Valley National High School. Specifically, the study sought to determine how concept mapping enhanced students' learning engagement, student motivation, and critical thinking and problem-solving, addressing the challenges of teaching this complex topic in the senior high school curriculum.

II. RESEARCH QUESTIONS

1. What are the test scores of the respondents before and after exposure to concept mapping teaching strategy?
2. What is the level of the assessment of the respondents on the effect of concept mapping strategy as used in teaching evolution in terms of student engagement, student motivation, and critical thinking and problem solving?
3. Is there a significant difference between the pretest scores and post-test scores of the respondents?
4. Is there a significant relationship between respondents' level of assessment and the post-test scores?

III. RESEARCH METHOD

The study employed a quantitative descriptive-correlational research design to determine the impact and relationship of the concept mapping strategy on the academic performance of Grade 11 students in learning evolution. The respondents of the study comprised of all seventy (70) Grade 11 students taking General Biology 2 at Sun Valley National High School in Parañaque City. This study utilized researcher-made Evolution Mastery Assessment (EMA) and Students' Assessments of the Effects of the Concept Mapping Strategy.

IV. RESULTS AND DISCUSSION

Table 1. Frequency and percentage distribution of pre-test and post-test results

			Pre-test		Post-test
Score range	Category	Frequency	Percentage	Frequency	Percentage
0–23	Did Not Meet Expectation	70	100	0	0
24–27	Fairly Satisfactory	0	0	3	4.3
28–31	Satisfactory	0	0	4	5.7
32–35	Very Satisfactory	0	0	11	15.7
36–40	Outstanding	0	0	52	74.3
Total		70	100	70	100

Table 1 shows a significant improvement in students' academic performance from pre-test to post-test. Initially, all 70 students (100%) scored within the *Did Not Meet Expectation* range (0–23), indicating minimal prior knowledge. No student reached higher performance categories. After the instructional intervention, all students improved. None remained in the lowest category; 3 (4.3%) reached *Fairly Satisfactory* (24–27), 4 (5.7%) achieved *Satisfactory* (28–31), 11 (15.7%) attained *Very Satisfactory* (32–35), and the majority, 52 students (74.3%), reached the *Outstanding* level (36–40), highlighting the intervention's effectiveness.

Table 2. Mean and standard deviation of pre-test and post-test results

	Mean	Std. Deviation
Pre-test	1.0000	.00000
Post-test	4.6000	.78758

Table 2 presents the statistical summary of student performance before and after the concept mapping strategy. The pre-test mean score was 1.0000 with no variability (SD = 0.00000), indicating uniformly low prior knowledge. Post-test results showed a substantial improvement, with the mean rising to 4.6000 and a standard deviation of 0.78758, reflecting high overall performance with slight individual differences. The marked increase in scores suggests that concept mapping was highly effective in enhancing student understanding and learning outcomes.

Table 3. Mean and standard deviation on the level of assessment of the respondents on the effect of concept mapping strategy as used in teaching evolution in terms of student engagement

Indicator	Mean	Standard Deviation	Verbal Description	Interpretation
1. I actively participated in the lessons when concept mapping was used.	3.0429	.46425	Agree	High - Positive Assessment
2. Concept mapping made the learning process more interactive and engaging.	3.2429	.49448	Agree	High - Positive Assessment
3. I felt more focused and attentive during classes that incorporated concept mapping.	3.0429	.52297	Agree	High - Positive Assessment
4. Concept mapping encouraged collaboration and discussion with my classmates.	3.1571	.47045	Agree	High - Positive Assessment
5. The use of concept mapping helped me stay interested in learning about evolution.	3.3857	.59692	Strongly Agree	Very High - Strong Positive Assessment
Overall Mean	**3.1743**	**0.5121**	Agree	**High - Positive Assessment**

* Legend:

Rating	Scale Range	Verbal Description	Interpretation
4	3.25 - 4.00	Strongly Agree	Very High (Strong Positive Assessment)
3	2.50 - 3.24	Agree	High (Positive Assessment)
2	1.75 - 2.49	Disagree	Low (Negative Assessment)
1	1.00 - 1.74	Strongly Disagree	Very Low (Strong Negative Assessment)

Table 3 summarizes students' perceptions of the concept mapping strategy in teaching evolution, particularly in terms of engagement. The overall weighted mean of 3.1743 (SD = 0.5121) falls under "Agree," indicating a positive response. The highest-rated item, "The use of concept mapping helped me stay interested in learning about evolution," received a weighted mean of 3.3857 (SD = 0.59692), categorized as "Strongly Agree." Other indicators also showed high ratings (means from 3.0429 to 3.2429), highlighting concept mapping's effectiveness in fostering interest, interactivity, collaboration, focus, and active participation. The low standard deviations suggest consistent student agreement, reinforcing the strategy's positive impact on engagement.

Table 4. Mean and standard deviation on the level of assessment of the respondents on the effect of concept mapping strategy as used in teaching evolution in terms of student motivation

Indicator	Weighted Mean	Standard Deviation	Verbal Description	Interpretation
1. Concept mapping increased my interest in learning about evolution.	3.2714	.58783	Strongly Agree	Very High - Strong Positive Assessment
2. I was motivated to explore and understand the relationships between concepts in evolution.	3.2571	.55653	Strongly Agree	Very High - Strong Positive Assessment
3. The visual representation of concepts helped me feel more confident in my learning.	3.2286	.51560	Agree	High - Positive Assessment

4. Concept mapping made me feel more in control of my learning process.	3.1429	.54602	Agree	High - Positive Assessment
5. The strategy inspired me to actively prepare and participate in class discussions.	3.1429	.51880	Agree	High - Positive Assessment
Overall Mean	**3.2086**	**0.5456**	**Agree**	**High - Positive Assessment**

* Legend: Rating Scale Range Verbal Description Interpretation

Rating	Scale Range	Verbal Description	Interpretation
4	3.25 - 4.00	Strongly Agree	Very High (Strong Positive Assessment)
3	2.50 - 3.24	Agree	High (Positive Assessment)
2	1.75 - 2.49	Disagree	Low (Negative Assessment)
1	1.00 - 1.74	Strongly Disagree	Very Low (Strong Negative Assessment)

Table 4 shows the impact of concept mapping on students' motivation in learning evolution. The overall weighted mean of 3.2086 (SD = 0.5456) falls under "Agree," reflecting a strong positive perception of its motivational effect. The highest-rated item, "Concept mapping increased my interest in learning about evolution," had a mean of 3.2714 (SD = 0.58783), categorized as "Strongly Agree." Other indicators, with means ranging from 3.1429 to 3.2571, also support the strategy's effectiveness in boosting curiosity, confidence, and self-directed learning. The consistently low standard deviations suggest uniform agreement among students on concept mapping's positive impact on motivation.

Table 5. Mean and standard deviation on the level of assessment of the respondents on the effect of concept mapping strategy as used in teaching evolution in terms of critical thinking and problem solving

Indicator	Weighted Mean	Standard Deviation	Verbal Description	Interpretation
1. Concept mapping helped me analyze and evaluate the relationships between evolutionary concepts.	3.3714	.56904	Strongly Agree	Very High - Strong Positive Assessment
2. The strategy encouraged me to think critically about how concepts are connected.	3.3429	.53530	Strongly Agree	Very High - Strong Positive Assessment
3. I was able to identify and solve problems more effectively using concept mapping.	3.2286	.59397	Agree	High - Positive Assessment
4. Concept mapping enhanced my ability to synthesize information and draw conclusions.	3.2571	.55653	Strongly Agree	Very High - Strong Positive Assessment
5. The use of concept mapping improved my ability to apply evolutionary concepts to real-world scenarios.	3.0714	.54697	Agree	High - Positive Assessment
Overall Mean	**3.2543**	**0.5607**	**Strongly Agree**	**Very High - Strong Positive Assessment**

* Legend: Rating Scale Range Verbal Description Interpretation

Rating	Scale Range	Verbal Description	Interpretation
4	3.25 - 4.00	Strongly Agree	Very High (Strong Positive Assessment)
3	2.50 - 3.24	Agree	High (Positive Assessment)
2	1.75 - 2.49	Disagree	Low (Negative Assessment)
1	1.00 - 1.74	Strongly Disagree	Very Low (Strong Negative Assessment)

Table 5 highlights the positive impact of concept mapping on students' critical thinking and problem-solving skills in learning evolution. The overall weighted mean of 3.2543 (SD = 0.5607) falls under "Strongly Agree," indicating a strong positive perception. The highest-rated item, "Concept mapping helped me analyse and evaluate the relationships between evolutionary concepts," had a mean of 3.3714 (SD = 0.56904), showing its effectiveness in enhancing analytical thinking. Other high-rated indicators, including those related to critical thinking, synthesis, and problem-solving (means ranging from 3.0714 to 3.3429), further support the strategy's role in deepening understanding. Even the lowest-rated item, applying concepts to real-world scenarios (Mean = 3.0714), was rated positively, suggesting potential for further instructional support. The low standard deviations reflect consistent agreement among students.

Table 6. Paired samples t-test on the significant difference between the pretest scores and post-test scores of the respondents

	Mean	Computed t- value	A	Sig. (2-tailed)	Decision on Ho	Interpretation
Pre-test	-3.60000	-38.243	.05	.000	Rejected Ho	Significant
Post-test						

Table 6 shows a significant difference between students' pre-test and post-test scores following the concept mapping intervention. The mean difference of -3.60000 and a t-value of -38.243 indicate a substantial improvement. With a p-value of 0.000 ($p < 0.05$), the result is statistically significant, leading to the rejection of the null hypothesis. This confirms the effectiveness of concept mapping in enhancing student performance.

Table 7. Pearson correlation on the significant rrelationship between the respondents' level of assessment and the post-test scores

Level	Pearson r	Degree of Relationship	*p*-value	α	Decision	Interpretation
Student Engagement	.107	Very Low positive	.379	.05	Accept Ho	Not Significant
Student Motivation	.079	Very Low positive	.518	.05	Accept Ho	Not Significant
Critical Thinking and Problem Solving	.159	Very Low positive	.187	.05	Accept Ho	Not Significant

*Legend:

r values	Interpretation
±1.00	Perfect positive/negative correlation
±.90 to ±.99	Very high positive/negative correlation
±.70 to ±.89	High positive/negative correlation
±.50 to ±.69	Moderate positive/negative correlation
±.30 to ±.49	Low positive/negative correlation
±.01 to ±.29	Very Low positive/negative correlation
0	No correlation

Table 7 reveals no statistically significant relationship between students' post-test scores and their assessments of engagement, motivation, and critical thinking. The Pearson r values—0.107 (engagement), 0.079 (motivation), and 0.159 (critical thinking/problem-solving)—indicate very low positive correlations. All corresponding p-values ($p > 0.05$) exceed the significance level, leading to the acceptance of the null hypothesis. This suggests that these variables, while slightly associated with performance, did not significantly influence post-test outcomes.

CONCLUSIONS

The study confirms that concept mapping is an effective instructional strategy that significantly enhances student comprehension, critical thinking, and academic performance in science education. It fosters engagement, motivation, collaboration, and deeper understanding of complex concepts. Although students positively perceived its impact, no significant correlation was found between these perceptions and post-test scores, indicating that other factors may also influence academic outcomes. Nonetheless, the overall improvement in performance underscores its instructional value. The proposed LAC training program further supports teacher capacity-building, promoting student-centered learning and improved outcomes through effective use of concept mapping.

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