Original Article
ISSN (Online): 2350-0530
ISSN (Print): 2394-3629

International Journal of Research - GRANTHAALAYAH
March 2025 13(3), 437–444

EFFECTIVENESS OF CONCEPT MAPPING ON STUDENTS' ACADEMIC ACHIEVEMENT IN BIOLOGY AT THE SECONDARY SCHOOL LEVEL

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Received 20 December 2024
Accepted 12 March 2025
Published 31 March 2025

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DOI
10.29121/granthaalayah.v13.i3.2025.6035

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ABSTRACT

Concept mapping is a powerful visual learning strategy that allows students to organize and structure information meaningfully. By representing relationships between concepts through diagrams, concept mapping enhances comprehension, memory retention, and critical thinking. This exploratory study investigates the effectiveness of concept mapping on the academic achievement of IX standard students in the topic The Cell in a secondary school in Moradabad. The study involved 60 students, who were divided into two groups—control and experimental—each comprising 30 students. A pre-test designed by the researcher was administered to assess the baseline knowledge of all participants. Following this, the control group received instruction through traditional teaching methods, while the experimental group was taught using concept mapping techniques, which involved the creation and discussion of visual concept diagrams to represent cellular components and their functions. After the instructional period, a post-test was conducted for both groups using the same test structure as the pre-test. The scores were analyzed statistically to determine if there was a significant difference in academic performance between the two groups. Results revealed that students taught through concept mapping performed significantly better than those taught through traditional methods. The experimental group showed improved comprehension and higher retention of the topic. These findings suggest that concept mapping is not only an effective instructional tool but also a student-centered strategy that promotes meaningful learning, especially in subjects like biology that involve abstract and complex content. In conclusion, this study supports the integration of concept mapping into secondary school science education. It demonstrates that when students actively engage in constructing knowledge visually, their ability to understand and retain information improves, thereby enhancing overall academic achievement.

Keywords: Concept Mapping, Academic Performance, Knowledge Retention, Student Motivation

1. INTRODUCTION

The teaching and learning process in secondary school biology presents unique challenges due to the susbject's complex concepts and diverse content areas Novak and Gowin (1984). Biology requires not only the method of collecting knowledge but also the improvement of skills in problem-solving and analysis Mintzes et al. (1998). As a result, educators continuously seek innovative strategies that can enhance students' understanding, retention, and application of biological concepts. Concept mapping, a visual learning aid that assists students in structuring and organizing their information, is one such method Novak (1990). Concept mapping

involves creating images that illustrate the relationships between different concepts, often using nodes and connecting lines or arrows to indicate how ideas are related. This technique is grounded in constructivist learning theory, which emphasizes the active role of learners in constructing their understanding based on prior knowledge Ausubel (1968), Novak and Cañas (2006). Research suggests that concept maps can facilitate meaningful learning by helping students visualize and connect new information with existing knowledge structures Novak and Cañas (2008), Nesbit and Adesope (2006). In recent years, the integration of concept mapping into biology instruction at the secondary school level has gained attention as an effective method for improving students' academic achievement Omar (2015). By encouraging deeper cognitive engagement, concept mapping has the potential to enhance both knowledge retention and understanding, leading to better performance in assessments Chiou (2008). Furthermore, it fosters critical thinking, problem-solving, and metacognitive skills, all of which are crucial in the study of biology Kinchin et al. (2000). The extent of the effectiveness of concept mapping in biology education in secondary school remains an area of ongoing research. The aim of this study is to explore the effect of concept mapping on students' academic achievement in biology or to examine its impact on knowledge acquisition, retention, and performance in secondary school. By examining how students use concept maps to structure their learning, this study seeks to provide valuable insights into the role of visual learning tools in enhancing educational outcomes.

1.1. CONCEPT MAP IN EDUCATION

Concept maps are a highly effective educational tool used to visually organize and represent knowledge, making complex information more accessible and understandable Novak and Cañas (2006). By illustrating the relationships between various concepts through interconnected nodes and labeled links, concept maps help students grasp the intricate subject matter and see how different ideas interrelate Nesbit and Adesope (2006) This visual approach not only aids in clarifying and simplifying complex topics but also enhances retention and comprehension by structuring information in a meaningful way Novak (1998). As students actively engage in creating and analyzing concept maps, they develop critical thinking and organizational skills and better integrate new information with their existing knowledge Kinchin et al. (2000). Concept maps also serve as valuable assessment tools, offering educators insights into students' understanding and ability to connect concepts Novak and Gowin (1984). Additionally, they accommodate diverse learning styles, promote collaborative learning, and support effective study and review practices Kinchin (2001). Overall, concept maps play a crucial role in facilitating deeper learning and understanding across various educational contexts.

1.2. RATIONAL OF THE STUDY

The need for effective instructional strategies in science education is critical, especially for ninth graders who are navigating increasingly complex concepts. Many students at this stage struggle with integrating and applying scientific knowledge, which can impede their overall academic performance. Concept mapping, a visual tool designed to help organize and represent relationships between concepts, has shown promise in enhancing comprehension and retention. Despite its potential benefits, there is limited research specifically focusing on its impact on eighth graders' science performance. This study aims to fill this gap by

investigating how concept mapping techniques influence students' understanding and academic outcomes in biology. The results could provide valuable insights for educators and policymakers, potentially leading to improved teaching methods and better support for students in mastering science concepts. By investigating the effectiveness of concept mapping, this research seeks to contribute to more effective biology education practices and ultimately enhance students' learning and achievement.

1.3. STATEMENT OF THE PROBLEM

"Effectiveness of Concept Mapping on students' Academic Achievement in biology at the Secondary School Level

1.4. OBJECTIVES OF THE STUDY

- To study the significant difference between the pre-test and post-test of academic achievement in biology of students in the Control & Experimental group.
- To study the significant difference between the pretest and posttest of academic achievement in the biology of boys' students in the Control & Experimental group.
- To study the significant difference between the pretest and posttest of academic achievement in the biology of girls' students in the Control & Experimental group.

1.5. HYPOTHESIS OF THE STUDY

- There is no significant difference between the pretest and posttest of academic achievement in the biology of students in the Control & Experimental group.
- There is no significant difference between the pretest and posttest of academic achievement in the biology of boys' students in the Control & Experimental group.
- There is no significant difference between the pretest and posttest of academic achievement in the biology of girls' students in the Control & Experimental groups.

1.6. DELIMITATIONS OF THE STUDY

This study is restricted to teaching or learning biology through the use of concept maps for Ninth-grade students in Moradabad district only.

2. RESEARCH METHODOLOGY

Research methodology consists of the research design, sampling design, development of tools and techniques, and statistical technique used for the present study.

1) **Design of the Study**: The study is Quasi-experimental in nature, where both control and experimental groups are considered.

2) **Sample of the Study**: The sample of the study consists of sixty students of IX standard studying in the CBSE School of Moradabad District. The sample was drawn based on random sampling techniques. Two sections 'A' and 'B' were selected wherein one (A) was the control group and the other (B) section was considered as the experimental group

2.1. VARIABLES OF THE STUDY

- **Independent Variables** Concept Mapping Method, Traditional Method
- **Dependent Variables** Academic Achievement in Biology

2.2. TOOLS USED IN THE STUDY

- Achievement test constructed by the researcher.
- Concept Mapping Module constructed by the researcher.

Statistical Techniques: The hypotheses of the study were tested by mean, SD and t-test

Table 1

Table 1 To Study the Significant Difference Between the Pre-Test and Post-Test of Academic Achievement in Biology of Students

Achievement	Mean (N=60)	SD	T-value	p-value	Significance
Pre-test	31.47	4			
Post-test	35	6.99	4.8	<0.0001	Significant Difference
Difference	3.53	5.69			

Interpretation: The results from Table 1 show a statistically significant difference between the students' pre-test and post-test scores. The mean score scaled from 31.47 in the pre-test to 35.0 in the post-test, for a mean difference of 3.53. The standard deviation values were 4.0 and 6.99, showing some variation in the results. The expected t-value was 4.80, and the p-value was less than 0.0001, which is significantly lower than the usually accepted standard of 0.05. The p-value is less than 0.05, hence this difference is considered statistically significant. The improvement in post-test results clearly indicates that the intervention improved students' academic performance. It suggests that the instructional intervention improved learning outcomes and may be consider as an effective technique for enhancing the achievement of students.

Table 2

Table 2 There is No Significant Difference Between the Pre-Test and Post-Test of Academic Achievement in Biology of Boys' Students

Achievement	Mean (N=41)	SD	T-value	p-value	Significance
Pre-test (boys)	15.2	2.6			
Post-test (boys)	16.6	3.5	2.06	<0.05	Significant Difference
Difference	1.4	4.36			

Interpretation: According to the data in Table 2, the t-value of 2.06 and p-value of 0.046 suggest a statistically significant difference between boys' pre-test and post-test scores on the Biology achievement. The mean score scaled from 15.2 in the pre-test to 16.6 in the post-test, for a mean difference of 1.4. The standard deviation values were 2.6 and 3.5, showing some variation in the results. The null hypothesis is rejected since the p-value is less than the conventional level of significance (0.05). This suggests that the observed score improvement was unlikely to occur by chance. The increase in post-test scores demonstrates that the Concept Module had a positive impact on the academic performance of male students. This significant improvement indicates that the module was successful in improving students' grasp of the subject. The findings confirm the effectiveness of the module's instructional technique and support its use in the classroom. Overall, the Concept Module is a beneficial tool for increasing boys' biology achievements, significantly contributing to their academic growth and educational outcomes.

Table 3

Table 3 There Is No Significant Difference Between the Pre-Test and Post-Test of Academic Achievement in Biology of Girls' Students

Achievement	Mean (N=19)	SD	T-value	p-value	Significance
Pre-test (Girls)	16.8	3.7			
Post-test (Girls)	19.6	3.2	2.5	<0.05	Significant Difference
Difference	2.8	4.89			

Interpretation: According to the data in the Table 3, the t-value of 2.50 and p-value less than 0.05 show a statistically significant difference between girls' pre-test and post-test scores on the Biology achievement examination. The mean score scaled from 16.8 in the pre-test to 19.6 in the post-test, for a mean difference of 2.8. The standard deviation values were 3.7 and 3.2, showing some variation in the results. We reject, rather than accept, the null hypothesis since the p-value is less than the standard of 0.05. This shows that the improvement in scores is not related to chance, but rather to the intervention. The positive change in the post-test scores demonstrates that the Concept Module had a beneficial impact on the academic performance of girls' students. This significant increase indicates that the module has improved their understanding as well as objectives in biology. The findings provide validity to the Concept Module's use as an effective teaching tool for raising girls' academic performance. Consequently, the module has a good impact on the educational growth of female students.

3. DISCUSSION AND CONCLUSION

- There is statistically significant difference between the pre-test and post-test scores of academic achievement in biology students. This suggests that the intervention have a measurable impact on the academic achievement of students in biology.
- There is statistically significant difference between the pre-test and post-test scores for boys. This positive change that the intervention has a measurable impact on the academic achievement of boys in biology.
- There is a statistically significant difference between the pre-test and post-test scores for girls. This positive change indicates that the

intervention contributed to an increase in academic achievement for girls in biology.

This study reveals that while the academic intervention resulted in a significant improvement in the biology achievement of girls, there was significant difference for boys. These findings suggest that the intervention may have been more effective for both male and female students, raising important questions about how teaching strategies can be tailored to meet the needs of different student groups. Since there was significant improvement, further investigation is required to understand why the intervention impact boys' academic achievement. Future studies could focus on adjusting teaching methods to better engage male students, possibly by incorporating more hands-on activities, competitive elements, or varied teaching approaches that appeal to boys' learning preferences. On the other hand, the positive outcomes for girls suggest that the intervention had a meaningful effect. This highlights the potential of similar interventions to improve academic outcomes for girls. However, it is essential to continue exploring which specific elements of the intervention worked well for girls, so these methods can be replicated and refined in future programs.

RECOMMENDATIONS

Future research should investigate whether gender-specific strategies or individualized teaching methods can help improve the academic performance of both boys and girls.

- Longitudinal research studies may also be valuable in monitoring the intervention's ongoing effect on academic achievement, taking into factors such as gender and other demographic variables.
- While this study demonstrates that academic interventions can have a positive impact on some students, there is a need for further refinement of these interventions to ensure that they are equally effective for all students, regardless of gender.
- Educational outcomes can be made more equal and successful by changing educational interventions to meet the various requirements of students.

EDUCATIONAL IMPLICATIONS

The findings of the research about Concept Mapping's effectiveness have several significant educational implications. To increase student understanding, preservation, and academic performance, concept mapping can be included into a variety of educational processes. The main educational implications are listed below:

- Teachers should use Concept Mapping as a tool to break down complex topics, allowing students to clearly see how different ideas are related. This can help improve long-term retention of the material.
- Teachers can use Concept Mapping to engage students in active learning. Rather than simply being passive recipients of information, students actively participate in organizing and understanding content, which can increase motivation and interest in the subject.

- Teachers can integrate Concept Mapping into problem-solving activities. This can help students understand the underlying structure of problems and develop more effective strategies for solving them.
- Teachers should consider using Concept Mapping in diverse classrooms. By offering this visual and interactive method, they can cater to different learning preferences, providing a more inclusive learning environment.
- Teachers can use Concept Maps as a form of informal assessment. By evaluating students' maps, teachers can gain insight into their learning process and adjust instruction accordingly.
- Teachers should encourage group work using Concept Maps. Collaboration helps students to clarify their thinking, and by discussing ideas, they may gain a deeper understanding of the content.

CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS

None.

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