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EFFECT OF CONCEPT MAPPING ON ACADEMIC ACHIEVEMENT OF GRADE VIII STUDENTS IN SCIENCE

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Abstract

Concept mapping functioned as an instructional technique to determine its effectiveness for improving General Science grades among Grade VIII students. The research design consisted of two groups from a government school where 57 female students received instruction. Experimental students numbered 29 and received teaching through concept mapping while control students consisted of 28 and learned through conventional methods. The achievement test for data collection was developed by the researcher and validated by experts before implementation. The KR-20 reliability analysis along with item testing confirmed its validity. Concept mapping education strategies enabled students to score better academically according to results obtained through independent t-test analysis. The strategy enabled students to understand science concepts better because it improved their conceptual understanding which results in better academic performance. The proposed research should expand to additional disciplines along with multiple learning environments.

Keywords: *Concept mapping, student achievement, instructional methods, science learning, secondary education, teaching strategies.*

Introduction

The quick progress in science and technology demands effective delivery of science education during elementary education that builds student understanding and questioning competency. Science education currently encounters multiple barriers because students tend to disengage from lessons while they struggle with abstract concept understanding and fail to remember most of the material (Wang & Tsai, 2023). Instructional techniques that are widely used need improvement due to their limited ability in handling current educational issues. The increasing need for modern teaching strategies emerges because these methods help students achieve better educational results and learning outcomes (Duschl & Bybee, 2022).

The discipline of science arranges knowledge through verified descriptions along with predictions regarding natural phenomena. Scientists use concept mapping method to produce new knowledge while upgrading current concepts before solving practical matters and extending human comprehension (Kang et al., 2018). The visual representation of associated data concepts together with their relationships is what concept mapping offers as an illustration method. Educators have shown great interest in this instructional technique because it strengthens scientific learning abilities among students (Chiou, 2023). The cognitive learning theories affirm this method because visual and organizational tools enable students to develop deep understanding which results in long-term retention (Zhou & Huang, 2021).

Multiple studies confirm that concept mapping leads to better learning results in scientific education due to science knowledge being organized through complex interconnected patterns. Students who developed concept maps integrated different types of knowledge better which

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enabled better mastery of information and higher academic results (Lee et al., 2022). Memorizing facts through rote learning produces students who miss essential ideas since they only remember basic facts. The practice of concept mapping allows students to create stronger connections with material which builds their scientific principle understanding (Wang et al., 2023). Concept mapping as a learning approach enhances memory retention because students achieve better post-test results in delayed assessments when compared to traditional teaching methods (Rahman & Singh, 2022).

Student performance evaluation enables educators to verify their students achieve complete understanding of fundamental concepts. The majority of educational institutions in Pakistan use final and annual exams which ends in pass or fail outcomes. The assessment methods hinder students' conceptual understanding and limit their potential to reach the highest levels of educational achievement (Khan et al., 2023). Elementary education prioritizes the National Science Curriculum by requiring students to master essential scientific concepts along with application and process utilization (Ministry of Education, 2021). Recent reforms push learners toward constructivist learning over behaviorist methods for improving science conceptual understanding (Ministry of Education, 2023).

Scientific mapping originates from David Ausubel's assimilation theory that supports knowledge organization according to Novak & Cañas (2022). The use of concept mapping leads to better student self-confidence and academic performance together with enhanced self-efficacy because it provides learners with control of their learning environment (Li et al., 2023). Various research projects documented worldwide verify the performance-enhancing effects of concept mapping on student success. The research conducted in Pakistan achieved better results through the implementation of concept mapping (Ahmad & Asghar, 2017; Fatima & Khalid, 2019; Rehman et al., 2015) in science subjects (Ali & Khan, 2024; Iqbal & Javed, 2023; Khan & Iqbal, 1990; 2010).

Rationale of the Study

Science education in modern times needs to be strong because it develops critical thinking abilities required for scientific development. The teaching methods in Pakistan rely mostly on rote memorization which produces difficulties for students when applying scientific information. Research shows concept mapping produces better results as an organizational system through its visual design to boost understanding and problem-solving among learners. Research about its impact on Grade VIII science education in Pakistani schools remains absent. The study examines concept mapping as a method to improve science achievement results. The observed low level of scientific achievement demonstrates both the necessity of conceptual learning and instructional strategies which must follow the National Curriculum (2022). Teachers together with their students require convenient approaches to master complicated science subjects. The study contributes to worldwide education excellence initiatives and upholds Sustainable Development Goal 4 for inclusive learning opportunities.

Objective of the Study

The objective of the study was to examine the effect of concept mapping on the academic achievement of Grade VIII students in General Science.

Hypotheses of the Study

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The following hypotheses were formulated for the study:

H_{01}: There is no significant effect of concept mapping on the pre-test academic achievement **of Grade VIII** science students **in the control and experimental groups.**

H_{02}: There is no significant effect of concept mapping on the post-test academic achievement **of Grade VIII science students in the control and experimental groups.**

H_{03}: There is no significant effect of concept mapping on the gain scores of academic achievements among Grade VIII science students.

Delimitations

The research examined only science as a subject among female students from Grade VIII in government schools while leaving out other academic disciplines along with mixed-gender or male student groups. The researcher established these boundaries to achieve both study focus and operational feasibility and resource management capacity within limited time period conditions.

Literature Review

Concept Mapping/Concept Maps

Concept mapping proves effective in research through its ability to develop critical thinking together with problem-solving abilities while enhancing knowledge storage (Hwang et al. 2023). When students used concept maps for STEM courses instead of traditional note-taking methods they achieved academic excellence alongside better conceptual understanding (Chang et al. 2024). Using specific topics for structured information depiction makes concept mapping an efficient learning method because of its graphical nature. Concept mapping in this method shows important ideas as nodes connected by relationship lines displayed through arrows or connecting lines. The method of deep learning emerges when people view concept relations alongside their processing activities and knowledge structure organization (Heng & Hsu, 2022).

Hussain and Tariq (2019) explored the use of concept mapping as a formative assessment tool in secondary schools in Pakistan. Their study revealed that concept maps enabled teachers to more accurately identify students' misconceptions, which led to more effective teaching strategies and improved academic performance among students. Studies demonstrate that implementing this technique fortifies self-learning capacity while advancing thinking process comprehension among students and promotes their active engagement in learning (Jiang & Yin, 2023). Visual aid concept mapping enables students to present concepts related to their subject while illustrating how different concepts depend on each other. According to Novak and Gowin (1984) concept maps from teachers or students present structured knowledge structures that show concept relationships describing hierarchical contexts. The primary focus of concept mapping lies in main ideas that serve as basic concepts but additional elements expand from this central part through directional arrows or connecting lines that show conceptual relationships between elements like causality or sequence or classification serve as essential components in these mapping structures.

The constructivist learning tool that concept maps provide encourages students to participate actively in reflective building of their knowledge structures (Novak & Cañas, 2006). Teamwork-based concept mapping produces enhanced communication as well as critical

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thinking abilities according to Hang et al. (2021) while building essential group competencies alongside increasing peer responsibility. Both educational tools concept mapping and concept maps demonstrate strong ability to boost students' knowledge organization skills coupled with critical thinking abilities and educational success.

The concept of learning meaningful material through cognitive structural connections forms the core of Ausubel's "Educational Psychology: A Cognitive View" which he presented in 1968. Building educational tools such as concept maps became possible after Ausubel revealed learning becomes more effective when students use existing knowledge as a foundation (Ausubel, 1968). The creation of concept maps developed into an efficient instrument for knowledge display which exposed interconnected concepts and essential patterns and themes (Chiapetta, 2006).

Students' concept maps showed misconceptions in their former educational content and the value of this mapping technique extended from training programs to primary and high school education as well as college learning (Canas et al., 2006). One more characteristics highlighted by Novak (1998) that 15- to 20-page transcript could be reduced to single-page concept map retaining all important concepts and propositions. According to Czarina and Haney (2018) collaborating on concept maps helps students build confidence, which in turn enhances their ability to handle challenging academic content.

Role of Concept Mapping in Science

The most effective results occur when science practice relates to concept maps (Vanides et al., 2005). The pictorial learning aids drive emphasis on essential scientific terms that students need for both laboratory work and classroom discussions. The highest impact of concept maps appears during two important phases of unit delivery, after completing sub-objectives or before understanding assessment. The use of concept maps is appropriate in lessons which demand a comprehension check before class advancement .The value of concept maps grows based on their ability to obtain essential student feedback for better learning outcomes (Vanides et al., 2005).

Science and math education demands students to demonstrate proficient problem-solving skills because they need to use the concepts they have learned (Ali & Khan, 2024; Khan & Iqbal, 1990; 2010). The problem-solving technique transforms difficult issues into smaller components that enable students to comprehend the problems better (Bascon & Novak, 1985). The use of concept mapping as an educational tool for physics students led to improved problem-solving abilities (Pankratius, 1990). The student outcomes from concept mapping instruction surpassed traditional teaching methods according to the obtained results while moderate effect size numbers (0.7) supported the effectiveness of concept mapping in science subjects.

Iqbal and Javed (2023) found that students from schools with limited access to textbooks and digital resources use concept mapping effectively to visualize relationships between ideas. They concluded that by using concept maps to grasp complex science concepts, students experienced less mental strain, which ultimately supported their academic success. The research conducted by Rahmani and Heydari (2023) together with Qureshi et al. (2022) demonstrates that science students show better conceptual understanding and higher motivation levels and academic results through the use of concept maps.

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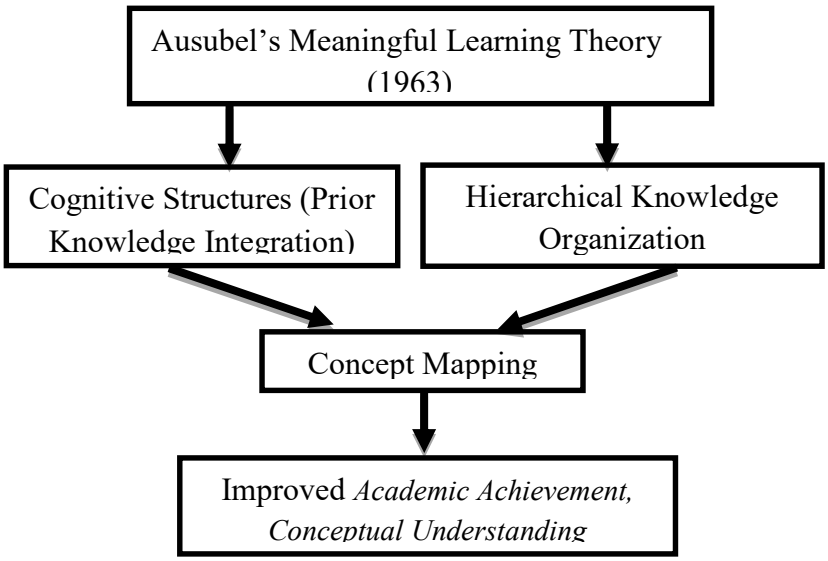
Theoretical Framework

According to Swanson (2013) a theoretical framework is "the structure that can hold or support a theory of a research study. It introduces and describes the theory that explains why the research problem under study exists" (p. 56). The study adopts Ausubel's Meaningful Learning Theory (1963) because it demonstrates that learners grasp information when new concepts link to their mental framework. The approach of meaningful learning enables students to grasp concepts more deeply alongside improved retention levels and useful practical abilities. The instructional approach of concept mapping applies concepts from Ausubel's theory by letting students generate visual diagrams that demonstrate hierarchical relations between new information and existing knowledge. According to Novak and Cañas (2022) structured learning that progresses from general concepts to specific ones is supported through concept map implementation. The system empowers concept mapping as an instrument to advance science achievement levels at secondary schools by assisting students in forming meaningful associations with academic content.

Figure 1

Schematic Diagram of the Theoretical Framework



Conceptual Framework

The study builds its conceptual framework because concept mapping functions as an impactful instructional approach for science education. Students learn better through visual concept organization because it structures their educational process to improve both scientific knowledge comprehension and retention. The learning theory of constructivism serves as

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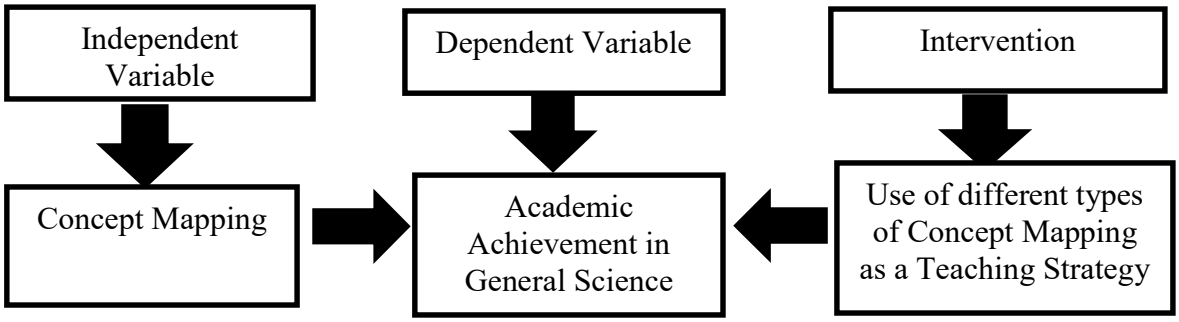
foundation for this evaluation framework because it promotes meaningful interactions between students and educational content.

This study incorporates student achievement analysis within its conceptual foundation along with teaching methods framework. Educational approaches under evaluation consist of standard lecture teaching and concept-mapping education methods. The researchers assume concept mapping as an instructional method leads to improved science achievement among students. The photographic visual featuring the research framework appears in Figure 2.4.

Figure 2 *Conceptual framework*



Research Methodology

Research Design

The research framework of this study relies on positivism through quantitative methods (Fraenkel et al., 2012). Under natural classroom settings the authors selected a quasi-experimental non-equivalent group design to study real differences between participant groups. The comparative method allows researchers to analyze groups through this approach because complete randomization remains a significant research obstacle in education (Cohen et al., 2018). The investigation uses the implementation of concept mapping as its independent variable to measure students' academic performance as the dependent variable. The research utilized a 16-week intervention duration during which both groups received pre-tests and post-tests to assess the intervention outcomes.

Population and Sampling

The research study examined Grade VIII science students attending a female government high school in Lahore. Section A contained 28 students as the control group while Section B had 29 students as the experimental group among the 57 total participants. A balloting system assigned students to the groups randomly to produce groups that matched on Grade VII final test scores. The research setup required this division to eliminate bias during selection and validate outcome findings.

Instrumentation

The General Science Achievement Test (GSAT) serves as the assessment tool designed by the researcher for measuring Grade VIII students' academic performance in General Science. The assessment tool consists of two equivalent forms which follow the Grade VIII General Science curriculum standards. The assessment contained 50 marks distributing into short-answer

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questions worth 2 marks each and multiple-choice questions keeping a value of 1 mark each. The GSAT initial development process used a Table of Specification (TOS) to distribute content from the learning outcomes and the cognitive levels (knowledge, understanding and application) in a balanced manner. The GSAT underwent a pilot test to check its reliability levels and validation properties before starting the main examination phase. The current investigation used 48 Grade VIII female students from a public sector school who joined this pilot test phase voluntarily. Instrument was modified after the data collected during pilot phase.

Reliability and Validity of the Instrument

The researcher utilized Kuder-Richardson Formula (KR-20) to measure the internal consistency of the GSAT because it works with dichotomously scored items. The data demonstrated acceptable reliability levels during research because the KR-20 reliability coefficient yielded 0.72. The test items functioned as an effective construct measurement method with dependable scoring properties among different testing times. A comprehensive Table of Specification (TOS) served as a method to establish the content validity throughout instrument development. The TOS systematically bound every assessment question to precise curriculum targets and intellectual learning areas. Science education experts validated the TOS to establish that the test covered all content areas and supported national curriculum standards.

Face validity was ensured when experienced science educators alongside assessment specialists assessed the instrument. The experts assessed the test items to determine their clarity and format and appropriateness. Subject matter experts validated that the assessment properly reflected educational concepts and suited Grade VIII students in the subject of science. The evaluation of item difficulty and discrimination indices determined through item analysis. The final GSAT version contained items consisting of well-designed components which successfully separated high-performing students from low-performing students through this evaluation process. The final test eliminated items which failed to fulfill accepted psychometric requirements by either being revised or removed.

Intervention

The research protocol spanned 16 weeks as both control subjects and experimental participants learned equivalent contents from the Grade VIII General Science curriculum. The instructional techniques implemented by both groups remained substantially different from each other. Traditional lecture-based instruction served as the control group teaching method which involved traditional verbal instruction coupled with textbook reading activities and note-taking. The experimental teaching approach in the group involved the utilization of concept mapping resources. Members of the experimental group developed their scientific concept understanding through hands-on work with hierarchical concept maps that they continuously improved. During this process students received chances to interact with their peers about their reasons as well as obtain feedback about their concept maps from the researcher.

Data Collection

The researchers conducted pre-tests and post-tests through the General Science Achievement Test (GSAT) to evaluate student academic achievement. Research started with baseline knowledge measurement i.e., pre-test for the control and experimental groups at the beginning of the experiment. The concept mapping instructional intervention followed by

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traditional teaching was provided to the experimental group but the control group received traditional teaching only. Posttest administered after this period. Both pre and posttest followed the curriculum standards while offering effective measurement of student knowledge improvement.

Data Analysis

The collected data were analyzed using descriptive and inferential statistical methods. Mean and standard deviation were used to summarize student performance. Independent samples t-test was applied to compare the gain scores of both groups and determine the effectiveness of concept mapping.

H_{01}: There is no significant effect of concept mapping on the pre-test academic performance **of Grade VIII** science students **in the control and experimental groups.**

Table 1

Mean Scores of the Experimental and Control Groups in the Pre-Test

	N	*M*	*SD*	Mean Difference	*p-value*
Experimental Group	29	21.27	3.98	-0.22	.828
Control Group	28	21.50	3.78		

*p≤ .05

The pre-test results from Table 1 show no significant difference (p = .828) between the groups, confirming similar academic performance before the intervention. The null hypothesis (**H_{01}**) is accepted.

H_{02}: There is no significant effect of concept mapping on the post-test academic performance of Grade VIII science students in the control and experimental groups.

Table 2

Mean Scores of the Experimental and Control Groups in the Post-Test

Group	*N*	*M*	*SD*	Mean Difference	*p-value*
Experimental Group	29	61.68	6.53	11.18	.000*
Control Group	28	50.50	5.89		

*p≤ .05

The post-test results from Table 2 show that the experimental group (M = 61.68, SD = 6.53) performed significantly better than the control group (M = 50.50, SD = 5.89) with a mean difference of 11.18 (p = .000). This rejects the null hypothesis (**H_{02}**).

H_{03}: There is no significant effect of concept mapping on the gain scores of academic achievements among Grade VIII science students.

Table 3

Group	*N*	*M*	*SD*	*Mean Difference*	Sig. (2-tailed)	Eta Square
Experimental Group	29	40.41	6.43	11.41	.000	0.42
Control Group	28	29.00	7.44			

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*p ≤ 0.05

From Table 3 concept mapping significantly improved students' performance (p = .000). The experimental group (M = 40.41, SD = 6.43) outscored the control group (M = 29.00, SD = 7.44) with a mean difference of 11.41. The large effect size (η^2 = 0.42) suggests a significant difference in gain sores. Since the p-value is ≤ 0.05, the null hypothesis (**H_{03}**) is rejected.

Discussion

The research demonstrates how concept mapping delivers beneficial results as an educational and instructional device that benefits sciences education specifically. The findings of this study align with various research evidence from across Pakistan, demonstrating how concept mapping enhances students' academic achievement. Students who learned with concept mapping at the secondary level according to Khan and Iqbal (1996) developed better problem-solving abilities with enhanced scientific concept understanding. Khan and Iqbal (2010) found that students understood science content significantly better while achieving higher marks when using concept mapping in their instruction. The research confirms that vision-based learning methods particularly concept mapping allow students to keep course material while making direct links between different academic concepts. The finding is also in alignment with Ali and Khan's study (2024) discovered that students who applied concept mapping made important advances in their learning of scientific material. Students benefit from knowledge visualization because it improves their ability to remember information while expanding the length of their knowledge retention. According to Czarina and Haney (2018) students enhance their confidence by working together on concept maps thereby improving their performance with challenging academic material.

This research confirms the findings from Hussain and Tariq (2019) conducted in schools at secondary level. The use of concept maps by teachers helped them detect student misconceptions more accurately which allowed them to teach students the right way which in result better achievement. Iqbal and Javed (2023) found that when students are benefited from concept mapping to understand complex science information, they reduced their mental strain which leads to their academic achievement. Hence, current research confirms that concept mapping proves to be an outstanding educational approach for science instruction because it yields positive outcomes.

Conclusion

From this study it is concluded that science students considered concept mapping to be an advantageous educational instructional device. Regardless of the learning environment students kept more information when teachers adopted concept mapping as their instructional method and students showed better results on post-tests than traditional lecture instruction. Students achieve better understanding of scientific concepts by using concept mapping because the method develops their ability to link concepts and build concept structures. The study showed concept mapping functions as an instructional tool that helps students think critically and develop their interest in science subjects which lead their improved academic achievement.

Recommendations

The research results provide basis for all suggested recommendations.

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- Educational guidelines should include concept mapping because such integration would improve student acquisition of learning objectives while helping students develop deeper comprehension.
- The classroom inclusion of concept mapping by science teachers produces better learning comprehension which leads to improved student motivation. This method helps students develop educationally while allowing their comprehension to build up.
- In order to effectively teach concept mapping both substantive theoretical knowledge and hands-on teaching methods are necessary for educators. Implementation of this strategy must become mandatory in professional training courses for becoming a teacher.
- VIII-grade students from General Science formed the research participant group. The broader use of concept mapping in learning needs further research to study its effects specifically on Mathematics and Social Sciences among different school grade levels.

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