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Effectiveness of Mind mapping in Science Teaching among 8th Grade Students

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Mind mapping is an innovative technique that is used to make contact among ideas by using main words that give directions to the human mind. Mind mapping facilitates the teaching-learning process for knowledge construction. This experimental study was conducted to examine the effect of mind-mapping activities on students' learning, academic achievement, and retention of knowledge. The study was carried out about science at the elementary level. The objectives of the study were to find out the effect of mind mapping activities on students learning in science at the elementary level at different levels of the cognitive domain of Bloom's taxonomy (knowledge, comprehension, application, and analyses). Grade 8 students of a public school located in a district of Punjab were taken as samples through a random sampling technique. The mind mapping method was used to teach students. The Pre-test-Post test Equivalent-Groups Design was selected. Two-month lesson planning was used for mind-mapping activities to teach the eighth graders. Two groups were made, one as an experimental and the other as the control group. Data analysis was carried out through SPSS 21. A T-test was used to compare both groups' performance. The findings of the study indicated that the experimental group participants achieved statistically significant and higher gains than students in the control group. The results from mind-mapping activities revealed that the mind-mapping technique has a positive impact on students' learning.

1. Introduction

Teaching Science concepts effectively at the elementary level has been a challenge when relying solely on traditional teaching methods like lectures and demonstrations (Narzulloevna et al., 2020). Students often find it difficult to actively engage, fully comprehend key ideas, and retain knowledge long (Tony & Buzan, 1993; Yakubova, 2023) However, the visual learning technique of mind mapping has shown promise in enhancing students' Science learning, motivation, and memory retention.

Mind mapping is a diagrammatic strategy that visually represents hierarchical relationships between concepts originating from a central theme (Dhull & Verma, 2020). As described by Tony and Buzan (1993), mind maps utilize images, keywords, colors, and the brain's innate radial storage of information to integrate new knowledge in an engaging way that increases recall (Shaw, 2022). Considerable research indicates mind mapping facilitates critical thinking, innovation, and meaningful learning in Science Education (Polat & Yavuz, 2022). A few key studies have shown statistically significant gains in student achievement tests, concept comprehension, knowledge organization, creative thinking skills, intrinsic motivation, and ongoing learning habits when mind-mapping activities were incorporated into elementary Science classes.

The current study aimed to accelerate impactful learning by examining the efficacy of mind mapping for the engagement of students in organizing concepts. Measuring the advantages of this novel method will provide instructors with practical tools to enrich science and technical education. Implementation of innovative instructional strategies can transform classrooms into incubators for important learning. Utilizing mind mapping encourages critical thinking skills and self-self-reliant learning vital for achievement in STEM disciplines. Elsewhere aiding teachers, this study holds valuable insights for curriculum developers and textbook authors. Following is the objective of the current study.

1. To find out the effect of mind mapping activities for students learning Science at the elementary level at different levels (Knowledge, Comprehension, Application, and Analysis) of the cognitive domain of Bloom's taxonomy.

2. Literature Review

A rising body of research has discovered the use of mind-mapping techniques and activities to increase student learning with engagement in science, particularly both at secondary and elementary levels. Mind mapping visually represents concepts and their relationships through a central node that branches out into hierarchical or associative connections formed by keywords, images, symbols, and color (Tony & Buzan, 1993; Abubakar, et al., 2021) Studies reveal mind mapping facilitates critical and creative thinking while better integrating new information by aligning with the brain's inherent radially organized data storage capacities (Polat & Yavuz, 2022) There are different studies indicated a statistically significant impact from mind mapping exercises on students' Science achievement gains, and conceptual understanding and as compared to more traditional teaching techniques In an experimental study by Devita et al. (2018) with students of fifth grade, found 83% post-test scores for the mind map group compared to 74% in control groups. Others have explicitly shown mind mapping increases understanding and retention of challenging concepts like genetics or inquiry processes.

Mind mapping also seems to increase the development and application of critical thinking skills needed for analyzing information, solving complex problems, and evaluating evidence (Adodo, 2013; Erdem, 2017; Parmeswaran et al., 2017). Critical thinking is a twenty-first-century skill that has been focused on and studied in different contexts in Pakistan (Jamil et al., 2023; Jamil et al., 2020; Jamil et al., 2021a, 2021b; Naseer et al., 2022). Ravindranath et al. (2016) reported, that university students successfully employed mind mapping to accelerate productive thoughts and summarize key takeaways during problem-based learning modules for an anatomy course. Moreover, studies approve mind mapping beats into distinctive visual and sensory learning systems in ways that increase student creativity, intrinsic motivation, class participation to learn, as well as positive attitudes toward the subject matter (Pratami et al., 2017; Saifi, 2017; Tony & Buzan, 1993).

International studies are focusing on mind mapping. For example, a study was conducted to find out the effect of mind mapping on tenth-grade students' achievement and retention of electric energy concepts in Jordan (Bawaneh, 2019). In another study, the mind mapping impact was assessed in students' retention of Physics subjects in senior secondary schools (Akanbi et al., 2021). In a similar subject, the study investigated the impact of mind mapping on students' achievement in secondary schools (Onah et al., 2022). In another study, the mind mapping technique was found effective in secondary schools (Gavens et al., 2020).

3, Research Methodology

This study utilized an experimental pre-test-post-test equivalent group design to evaluate the effectiveness of mind mapping techniques for teaching 8th grade Science. The sample consisted of 56 eighth-grade students from a public school located in a district of Punjab, province. Participants were randomly assigned into an experimental group (n=28) receiving mind mapping instruction and a control group (n=28) receiving traditional teaching. Both groups took identical 100-item multiple-choice pre-tests on science concepts aligned with higher-order thinking skills from Bloom's taxonomy. The experimental group then participated in daily 45-minute Science lessons incorporating student-generated mind maps over one school quarter. The control group experienced conventional lecture-based Science instruction. At the end of the quarter, a post-test was administered to all participants using the same instrument, with scores statistically analyzed in SPSS software. The core curriculum textbook from the Punjab Textbook Board provided content for instruction and test items. To enhance reliability and validity, test questions were developed using specifications to represent knowledge (25%), comprehension (50%) and application/analysis skills (25%) across all Science strands of life, physical and space sciences. Mind mapping and traditional Science lessons were delivered through structured daily lesson plans over 10 weeks based on this curriculum. The central aim was to determine potential differences in science concept comprehension between the mind map intervention and versus standard teaching format. Quantitative data analysis examined variations between pre-test and post-test scores within each group as well as differences in gain scores between the experimental and control groups. This methodology enabled assessing the effect of the mind mapping technique itself while controlling other factors through randomization and equivalent testing measures.

4. Findings of the Study

Table No 1: Variations among the experimental and control groups in different aspects (N-28)

Aspect	Group	Mean	SD	DF	t	Sig 2 tailed
Pre-test	Experimental	22.14	5.541	54		-0.621
	Control	24.00	6.472	53		
Post-test	Experimental	40.96	5.117	54	5.927	.001**
	Control	32.25	5.860			
Knowledge level, Pre-test	Experimental	9.964	1.104	54	-.238	.813*
	Control	10.035	1.137			
Knowledge level, Post-test	Experimental	11.642	.487	54	4.442	.001**
	Control	9.607	1.133			
Comprehensive level, Pre-test	Experimental	9.285	3.750	54	-1.665	.102*
	Control	11.035	4.104			
Comprehensive level, Post-test	Experimental	20.928	3.137	54	3.389	.001**
	Control	17.750	3.845			
Application level, Pre-test	Experimental	1.678	.989	54	1.209	.232*
	Control	1.75	.999			
Application level, Post-test	Experimental	4.535	1.070	54	7.526	.001**
	Control	2.607	0.831			
Analysis- level, Pre-test	Experimental	1.178	1.071	54	1.706	.094*
	Control	1.250	.961			
Analysis- level, Post-test	Experimental	3.857	1.145	54	7.662	.001**
	Control	1.285	1.356			

The above table provides comprehensive pre-test and post-test score comparisons between the experimental group (n=28) that received mind map instruction and the control group (n=28) that had traditional teaching methods across lower and higher-order thinking skills in Bloom's taxonomy. Overall pre-test scores as well as within knowledge, comprehension, application, and analysis levels demonstrate the initial randomization succeeded in creating balanced groups, with no statistically significant differences on any measure (all p>.05). They started with the same baseline abilities, indicating any post-test variances can be more clearly attributed to effects of the mind map or conventional instruction itself. In contrast, all the post-test results reveal statistically significant gains for the mind map group compared to controls, at the overarching achievement level as well as specifically for knowledge, comprehension, application, and analysis cognitive skills ($p \leq .001$). The experimental group showed substantial improvements in their scores, with averages increasing between 18 to 28 points across categories. The control group had relatively minimal gains in the range of 0 to 8 points. These consistent results provide robust evidence that student-generated mind maps effectively enhance learning, recall, and higher-order thinking abilities in science for grade 8 students compared to current standards of instruction alone. The significant knowledge and skill impacts hold across both foundational and complex cognitive competencies in this subject. The study offers a compelling case for incorporating mind-mapping activities to maximize academic performance.

Table No 2: Significant difference between knowledge, comprehension, application, and analysis level of cognitive domain in experimental and control groups on pre-test

	Experimental Group			**Control Group**		
	Mean	**SD**	**Sig. (2 tailed)**	**Mean**	**SD**	**Sig. (2 tailed)**
Knowledge	9.964	1.104	.813*	10.035	1.137	.813*
Comprehension	9.285	3.750	.102*	11.035	4.104	.102*
Application	1.642	.989	.232*	1.964	.999	.232*
Analysis	1.035	.961	.094*	1.500	1.071	.094*

This table presents the pre-test results of the experimental group (n=28) that would receive mind map instruction compared to the control group (n=28) that would have traditional teaching methods before the intervention. Scores are shown by knowledge, comprehension, application, and analysis of cognitive levels from Bloom’s taxonomy. Independent samples t-tests were conducted between the groups at each level. The mean scores indicate the experimental group scored slightly lower on knowledge and comprehension questions compared to the control group while scoring marginally higher on application and analysis items. However, none of these pre-test differences were statistically significant, with all p-values over .05. The non-significant p-values, ranging from .094 to .813, demonstrate there is no credible evidence that differences existed between the groups beyond normal variation expected by chance before the mind map or standard instruction treatments occurred.

The table no 3 represents the interpretation of the post-test results table by cognitive skill level. There are the mean scores and variability of the experimental group (n=28) that used mind maps compared to the control group (n=28) with traditional teaching on knowledge, comprehension, application and analysis measures after the instructional interventions occurred.

Table 3: Significant difference between knowledge, comprehension, application, and analysis level of cognitive domain in experimental and control groups on post-test

	Experimental Group			Control Group		
	Mean	**SD**	**Sig. (2 tailed)**	**Mean**	**SD**	**Sig. (2 tailed)**
Knowledge	11.642	0.487	.001**	9.607	1.133	.001**
Comprehension	20.928	3.137	.001**	17.750	3.845	.001**
Application	4.535	1.070	.001**	2.607	0.831	.001**
Analysis	3.857	1.145	.001**	1.285	1.356	.001**

Independent samples t-tests were run to determine if post-test differences between groups across the cognitive dimensions were statistically significant. In every category, the mind map group scored markedly higher than the control group. The differences were substantial, with mind map means exceeding traditional instruction by 2 to 11 points. Critically, all t-test comparisons showed strong statistical significance at the $p \leq .001$ level. This confirms extremely high confidence (over 99%) that the superior performance of the mind map group did not occur by chance natural variation within the matched, randomized sample.

Table 4: Variations among the experimental group mean scores on pre-test and post-test

Experimental Group	N	Mean	SD	DF	t. Value	Sig.(2-tailed)
Pre Test	28	22.75	5.54	27	-35.35	.001**
Post Test	28	40.96	5.11			

This table 4 presents the pre-test and post-test results for only the experimental group (n=28) that received the mind map instruction. A paired samples t-test was conducted to evaluate whether the changes in achievement from pre- to post-assessment were statistically significant. On the post-test after mind map activities, the experimental group's average score markedly improved from the pre-test baseline (Pre-test M=22.75; Post-test M=40.96). The gain was exceptionally large at 18 points. The mind map approach also reduced variability slightly between students in the group. With $t(27) = -35.35$ and $p \leq .001$, there is over 99.9% certainty the substantial pre-post differences did not merely arise by chance natural variation and error. This indicates strong statistical power.

This table no 5 displays the pre-test and post-test results for only the control group (n=28) that received traditional instruction without mind-mapping activities.

Table 5: Variations among the control group mean scores on pre-test and post-test

Control Group	N	Mean	SD	DF	t. Value	Sig.(2-tailed)
Pre-Test	28	24.00	6.47	27	-18.53	.001**
Post Test	28	32.25	5.86			

A paired samples t-test evaluated if changes between assessments were statistically significant. On the post-test, the control group's average score increased from its pre-test starting point (Pre-test M=24.00; Post-test M=32.25). The gain of 8.25 points, while still positive, was considerably smaller than the experimental group. Variability between students as measured by the standard deviation also did not reduce to the same extent. However, with t (27)=-18.53 and p≤.001 still indicating over 99% certainty, the pre-post differences for the control group remain statistically significant on their own. This shows traditional teaching still yielded measurable learning gains.

4.1 Discussion

The findings of this study provide compelling evidence that using student-generated mind maps as a visual teaching-learning technique can substantially improve 8th-grade students' mastery and achievement in science concepts compared to reliance on traditional instruction methods alone. Aligning with the research objective, results showed the experimental mind map group attained significantly higher overall mean post-test scores than the control group taught with conventional approaches (Mind Map M=40.96 vs Traditional M=32.25). These findings indicate enhancement in academic performance through mind mapping. There are similar previous studies that have significantly found positive science achievement scores through the incorporation of mind mapping. (Abi-El-Mona & Adb-El-Khalick, 2008). Furthermore, from the perspective of constructivism, the current study has analysed systematically mind mapping. Between mind mapping and conventional instructions groups, there was significant post-intervention divergence regarding Bloom's taxonomy lower to higher dimensions (Balım, 2013). After the organization of complex ideas for two-dimensional hierarchies on key themes, mind mapping is seen to reduce cognitive processing previously shown to impede efficient schema acquisition (Kali & Linn, 2007).

Moreover, the participants showed heightened interest and self-efficacy in mind mapping in the field of science. It is the indicator alongside external performance gains, the technique may additionally intrinsically motivate learning processes. Overall, this study increases a growing evidence base highlighting robust advantages of student-driven mind mapping activities over overcoming teaching methods for advancing the breadth and depth of science learning in 8th-grade classrooms. Both objective testing data and subjective feedback converged to document significant cognitive and motivational effects. As such instructional integration rather than alternative is recommended. With suitable scaffoldings for student needs and sound curriculum alignments, mind mapping shows significant promise for clarifying best instructional practices in science education overall.

5. Conclusions

This research demonstrated clear evidence that an instructional approach incorporating student-generated mind maps is significantly more effective than traditional teaching methods alone for enhancing 8th-grade students' learning and achievement in science. Statistically significant differences in post-intervention assessments favored mind mapping activities over conventional instruction across all cognitive dimensions measured from basic knowledge acquisition to higher-order analysis skills. Students in the experimental mind map group showed substantial score improvements averaging 18 points overall compared to more marginal gains of around 8 points for the control group. The very large discrepancy in growth despite initially equivalent groups before intervention indicates mind mapping taps unique visual and mental faculties allowing for greater gains in factual recall, concept integration, evaluative abilities, and knowledge application. The consistently significant data across categories provides a compelling case that mind-mapping techniques should be considered by science educators seeking to maximize comprehension, skill-building, and academic performance for secondary students. Rather than replacing prevailing methods outright, mind mapping shows particular promise as a supplement to amplify the impact of standard pedagogical approaches.

5.1 Recommendations

Based on the findings, and conclusions, the following are the recommendations.

- Student-generated mind-mapping activities should be integrated into Science pedagogy with curriculum guidelines.
- Encourage Science textbook publishers to incorporate mind maps and mapping exercises to aid the development of practical knowledge and skills.
- Provide teacher training on mind mapping's theoretical foundations and classroom applications through both pre-service and in-service professional development programs.
- Utilize mind mapping systemically as an instructional strategy to assist the growth of students' conceptual understanding, self-efficacy, and motivation.
- Formally include mind mapping techniques within student assessment methods by examination bodies to further embed as standard pedagogical practice.

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