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THE EFFECTIVENESS OF MIND MAPPING ON THE DEVELOPMENT OF CRITICAL THINKING SKILLS IN SECONDARY EDUCATION

Dilsora Ashurova
Trainee Teacher at Uzbekistan State World Languages University, Uzbekistan

Abstract: Mind mapping has evolved from a creative brainstorming aid into an instructional strategy that promises measurable cognitive dividends. Pre- and post-testing with the California Critical Thinking Skills Test and classroom discourse analysis revealed statistically significant gains for the experimental cohort in interpretation, inference and self-regulation subscales ($p < 0.01$). Qualitative classroom observations further indicated richer argumentative dialogue and greater metacognitive awareness among mind-mapping participants. The discussion positions these outcomes within constructivist theory, highlighting the technique's dual role as an external memory aid and a scaffold for dialogic reasoning. Implications for teacher training, curriculum design and future longitudinal research are proposed.

Keywords : Mind mapping; critical thinking; secondary education; visual learning; quasi-experiment.

INTRODUCTION

Critical thinking is heralded as the "signature outcome" of twenty-first-century schooling, yet large-scale assessments still report widespread deficits among secondary graduates (Santiago, 2011). Mind mapping—popularised by Buzan and later refined through digital tools—offers a theoretically coherent solution. By externalising hierarchical and lateral associations on a single plane, a mind map approximates the brain's natural associative networks, potentially reducing cognitive load and freeing attentional resources for evaluation and synthesis. Recent meta-analyses have begun to document positive, albeit heterogeneous, effects of mind maps on university students' reasoning; far less is known about younger learners whose neural plasticity and motivational profiles differ markedly.

Recent discipline-specific investigations point to encouraging trends. In Saudi respiratory therapy programmes, Turkestani et al. demonstrated significant post-intervention gains across all California Critical Thinking Skills Test (CCTST) domains following structured mind-map activities. Hazaymeh and Alomery recorded similar improvements among Emirati secondary-level English learners, attributing the effect to the way visual mapping simplifies textual macro- and micro-structures, supporting analytical rereading strategies

Despite converging evidence, gaps persist. Many studies focus on tertiary populations or narrow subject areas, employ small samples, or neglect control groups. Moreover, cross-cultural replication remains scarce, and few investigations track classroom dialogue—an essential mediator of reasoning development. The present study addresses these lacunae by examining a sizeable, diverse secondary sample across multiple subjects, employing a robust

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quasi-experimental design, and triangulating quantitative test scores with qualitative discourse analysis.

Grounding the inquiry is a constructivist framework that views learning as the active construction of interconnected mental schemata. From this perspective, mind maps serve not merely as mnemonic devices but as epistemic mediators that help learners visualise argumentative structures, evaluate competing claims and integrate new information with prior knowledge. If this framework holds, systematic embedding of mind-mapping exercises should yield observable gains in critical-thinking performance relative to traditional instruction.

Over a 12-week term the experimental classes integrated mind-mapping tasks into history and biology units. Teachers, trained during a two-day workshop, followed a uniform protocol: (1) a five-minute explicit demonstration of radial structuring principles; (2) individual or small-group mapping of lesson concepts using colour-coded branches and image cues; (3) plenary peer critique emphasising reasoning clarity; (4) iterative refinement. Digital freeware (FreeMind) was optionally employed in computer-equipped sessions; otherwise, pupils used A3 sheets and markers. Control classes covered identical curricular content via lecture-discussion, graphic organisers and textbook summaries but without mind maps.

Primary outcomes were measured with the standardised CCTST, Russian version, which reports subscale scores for analysis, inference, interpretation, evaluation, explanation and self-regulation. Cronbach's α for the study sample was 0.82. To capture discourse-level changes, two 40-minute lessons per class (weeks 4 and 10) were video-recorded and coded using Mercer's dialogic enquiry framework, focusing on cumulative, disputational and exploratory talk episodes.

Pre-post CCTST data were analysed using mixed-model ANCOVA with pre-test scores as covariates. Effect sizes were computed as partial η^2. Discourse counts were compared via chi-square tests. Qualitative field notes from weekly observations were inductively coded to contextualise quantitative trends.

Post-test means revealed sizeable advantages for the experimental group on overall CCTST ($M = 83.4$, $SD = 5.6$) versus controls ($M = 77.1$, $SD = 6.1$), $F(1, 309) = 52.7$, $p < 0.001$, $\eta^2 = 0.145$. Subscale analyses indicated the largest gains in interpretation ($\eta^2 = 0.132$) and inference ($\eta^2 = 0.118$), followed by explanation and self-regulation. Analysis and evaluation improved modestly yet significantly ($p < 0.05$). Gender did not interact with treatment effects.

Exploratory talk episodes—characterised by reasoned challenge and cumulative elaboration—rose from a baseline mean of 7.6 to 18.9 per lesson in the experimental condition, whereas controls increased marginally from 8.1 to 9.4. Chi-square comparisons confirmed a significant shift toward dialogic exchanges ($\chi^2 = 42.3$, $p < 0.001$). Field notes noted that mind-mapping sessions fostered collective visual reference points; pupils frequently gestured to branches when clarifying causal connections, which in turn grounded peer critique in shared artefacts.

The findings corroborate and extend earlier tertiary-level studies by demonstrating that systematic mind-mapping integration can meaningfully enhance critical-thinking capacities among younger learners. The pronounced gains in interpretation and inference suggest that visualising semantic relationships—cause-effect, part-whole, temporal sequence—primes pupils to decode and synthesise new evidence more efficiently. Such an interpretation aligns with dual-coding theory: combining verbal and non-verbal channels enriches mental representation and deepens processing (Santiago, 2011).

The discourse analysis provides mechanistic insight. Maps acted as shared cognitive artefacts that anchored exploratory talk, supporting Mercer's assertion that external representations trigger joint reasoning episodes. This mediating role may explain why effect sizes exceeded those reported in one-off laboratory studies (Hazaymeh & Alomery, 2022): prolonged, socially situated practice appears crucial. Comparable patterns emerged in STEM contexts where mind maps bridged abstract algorithms and real-world problems (Guo et al., 2024).

Limitations include quasi-experimental group assignment and reliance on a single standardised test. Although classroom heterogeneity enhances ecological validity, randomised designs across broader cultural settings would strengthen causal inference. Incorporating think-aloud protocols could further illuminate individual cognitive moves during map construction.

This study provides robust classroom-level evidence that mind mapping, when embedded in routine instruction, substantially promotes critical-thinking development in secondary education. Beyond boosting test scores, the technique nurtures dialogic classroom cultures where ideas are jointly constructed and scrutinised. For policymakers seeking scalable interventions aligned with twenty-first-century competencies, mind mapping represents a low-cost, high-impact strategy. Scaling efforts should prioritise teacher professional development, integration with digital platforms, and alignment with assessment rubrics that value analytical depth and argumentative rigour.

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