

FOSTERING ENGLISH READING SKILLS VIA VISUAL CLUSTERING FRAMEWORKS

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Abstract: Second language (L2) reading comprehension presents substantial cognitive challenges for English as a Foreign/Second Language (EFL/ESL) learners when processing complex expository texts. This article presents a synthesis and methodological evaluation of cluster technology—encompassing mind mapping, concept mapping, and digital Kit-Build mapping systems—as a cognitive scaffolding tool in L2 reading pedagogy. Grounded in Dual Coding Theory, Schema Theory, and Cognitive Load Theory, the paper details a structured three-stage instructional framework (Pre-Reading, While-Reading, and Post-Reading). Quantitative empirical evidence demonstrates that cluster technology produces statistically significant gains in L2 reading comprehension (Hedges' $g = 1.047$; $F = 23.55$, $p < .001$). Furthermore, alignment between text genre and organizer structure significantly enhances summarization performance ($t(199) = 6.94$, $p < .001$, $d = 0.56$), while digital Kit-Build mapping with source connections promotes long-term delayed retention (86% recall vs. 42% for traditional underlining). Pedagogical recommendations are provided to help educators optimize visual cartography in language classrooms.

Keywords: cluster technology, mind mapping, concept mapping, EFL reading skills, Schema Theory, Dual Coding Theory, Kit-Build system, graphic organizers.

Annotatsiya. Ingliz tilini xorijiy yoki ikkinchi til sifatida o‘rganuvchilar uchun murakkab axborot beruvchi matnlarni o‘qib tushunish sezilarli kognitiv qiyinchiliklarni yuzaga keltiradi. Mazkur maqolada ikkinchi tilda o‘qish metodikasida kognitiv tayanch vositasi sifatida klaster texnologiyasining, jumladan, aqliy xaritalar, konseptual xaritalar va raqamli Kit-Build xaritalash tizimlarining imkoniyatlari umumlashtiriladi va metodik jihatdan baholanadi. Ikki tomonlama kodlash nazariyasi, sxemalar nazariyasi va kognitiv yuklama nazariyasiga asoslanib, o‘qitishning uch bosqichli tizimli modeli — o‘qishdan oldingi, o‘qish jarayonidagi va o‘qishdan keyingi bosqichlar — yoritiladi. Miqdoriy empirik dalillar klaster texnologiyasi ikkinchi tilda o‘qib tushunish ko‘nikmalarini statistik jihatdan sezilarli darajada yaxshilashini ko‘rsatadi (Hedges' $g = 1,047$; $F = 23,55$; $p < 0,001$). Bundan tashqari, matn janri bilan grafik tashkil etuvchi tuzilmasining o‘zaro muvofiqligi mazmunni umumlashtirish natijalarini sezilarli darajada yaxshilaydi ($t(199) = 6,94$; $p < 0,001$; $d = 0,56$). Manbalar o‘rtasidagi bog‘lanishlarni aks ettiruvchi raqamli Kit-Build xaritalash tizimi esa uzoq muddatli kechiktirilgan eslab qolish ko‘rsatkichini oshiradi (an’anaviy tagiga chizish usulidagi 42 foizga nisbatan 86 foiz). Maqolada til darslarida vizual xaritalash usullaridan samarali foydalanish uchun pedagogik tavsiyalar beriladi.

Kalit soʻzlar: klaster texnologiyasi, aqliy xaritalar, konseptual xaritalar, ingliz tilida oʻqish koʻnikmalari, sxemalar nazariyasi, ikki tomonlama kodlash nazariyasi, Kit-Build tizimi, grafik tashkil etuvchilar.

1. INTRODUCTION

1.1 Background and Problem Statement

Mastering second language (L2) reading skills is foundational to academic success for English as a Foreign Language (EFL) students. However, L2 readers frequently encounter severe cognitive bottlenecks when processing dense, syntactically intricate academic prose. Traditional L2 reading instruction heavily relies on linear decoding and translation, which fails to foster high-order cognitive processing. Learners struggle to extract macrostructures and trace logical relationships across paragraphs, leading to superficial comprehension, reading anxiety, and rapid information decay.

To mitigate these hurdles, educational research has increasingly emphasized visual scaffolding tools. Among these, 'cluster technology'—encompassing mind mapping, concept mapping, semantic mapping, and digital graphic organizers—has emerged as a transformative technique. By translating linear textual information into multidimensional spatial networks of nodes and labeled links, cluster technology externalizes cognitive representations. This article investigates the theoretical mechanisms, instructional methodologies, and empirical effectiveness of cluster technology in enhancing L2 reading comprehension.

1.2 Theoretical Foundations

The instructional efficacy of cluster technology rests upon three core cognitive frameworks that explain how visual mapping optimizes learning:

- **Dual Coding Theory (Paivio, 1986):** Human cognition processes information through two subsystems: a verbal channel for linguistic logogens and a visual channel for spatial imagens. Cluster technology engages both channels simultaneously by coupling lexical nodes with spatial layouts, colors, and directional links. This dual-code presentation creates dual memory traces, enhancing text recall and semantic decoding efficiency.

- **Schema Theory (Ausubel, 1968; Rumelhart, 1980):** Reading comprehension is an active process where readers map textual data onto pre-existing cognitive schemata. Cluster organizers act as visual advance anchors. By laying out overarching topics, main ideas, and details in a clear hierarchy, clustering activates relevant content and formal schemata, allowing L2 readers to fit new information into organized mental frameworks.

- **Cognitive Load Theory (Sweller, 1988) & Metacognitive Monitoring:** Working memory capacity is strictly finite, especially for L2 readers expending resources on low-level decoding. Unstructured academic text imposes high extraneous cognitive load. Visual clustering offloads structural organization onto an external visual medium, freeing working memory capacity for higher-level inferential reasoning and metacognitive self-monitoring (Flavell, 1979; Anderson, 2002).

1.3 Taxonomy and Operational Scope

To operationalize 'cluster technology' within instructional contexts, four primary visual cartography formats are distinguished:

1. Mind Mapping (Buzan, 1993): A radiant, non-linear visual diagram originating from a central concept, using branches, keywords, and colors for open-ended brainstorming and narrative text mapping.

2. Concept Mapping (Novak & Gowin, 1984): A structured, hierarchical node-link network where concepts are enclosed in boxes and connected via labeled verbs (propositions), ideal for expository and technical texts.

3. Graphic Organizers (T-Charts, Venn Diagrams): Visual diagrams engineered to match explicit text structures, such as cause-and-effect chains or compare-and-contrast tables.

4. Closed-Ended Digital Kit-Build Systems: Automated digital environments (Kit-Build) where learners construct maps from pre-cut nodes and connectors, receiving instant diagnostic feedback and source-connection links.

1.4 Research Questions

This study addresses three formal research questions (RQs):

- **RQ1:** What is the quantitative impact of cluster technology on L2 reading comprehension performance?
- **RQ2:** How does alignment between visual organizer structures (e.g., T-charts vs. Venn diagrams) and text genres influence L2 summarization accuracy?
- **RQ3:** What are the comparative retention affordances of student-generated mapping versus closed-ended digital Kit-Build mapping systems?

2. METHODOLOGY

2.1 Synthesized Research Designs and Sample Contexts

This study synthesizes data from empirical investigations across secondary and tertiary EFL contexts. The corpus incorporates mixed-methods designs (Marginingsih et al., 2025, N = 200), quasi-experimental pre/post-test designs (Saori, 2020, N = 34; Phan Thuy Trang, 2017, N = 64; Khatimah & Rachman, 2018, N = 72; Andoko et al., 2020, N = 232), Quade's ANCOVA trials (Tsai, 2025, N = 80), and digital concept mapping evaluations (Alkhateeb et al., 2016, N = 8). Psychometric integrity across studies was verified via high inter-rater agreement (ICC = .807; Cohen's Kappa = 0.76) and internal consistency (Cronbach's Alpha = 0.84).

2.2 The Three-Stage Pedagogical Sequence

The core methodology relies on a structured three-stage pedagogical routine that embeds visual cartography across the reading cycle:

Stage 1: Pre-Reading (Schema Activation & Topic Clustering)

Before reading, the instructor places the central topic at the core of a board or screen. Students participate in guided brainstorming to generate background concepts and vocabulary. Organizing initial predictions into sub-clusters activates content schemata and lowers L2 reading anxiety.

Stage 2: While-Reading (Active Extraction & Structural Mapping)

During reading, students scan the passage for discourse markers ('consequently', 'however') and core propositions. Learners transcribe primary concepts onto branching nodes and details onto sub-nodes, explicitly labeling connecting lines with relational verbs to map text structures in real time.

Stage 3: Post-Reading (Synthesis, Peer Verification, and Summarization)

Following reading, learners use completed visual clusters as roadmaps to write concise, non-

verbatim text summaries. During peer review, students compare map hierarchies to identify missing links and clarify misconceptions, while instructors evaluate comprehension depth.

2.3 Technological Implementations

Cluster technology spans three modalities: (1) Paper-based mapping for tactile engagement; (2) Digital Mind Mapping software (iMindMap, Canva, XMind) for color-coding and dynamic node manipulation; and (3) Closed-ended Kit-Build (KB) digital systems, where learners reconstruct expert maps with automated 'source-connection' feedback that highlights corresponding source text paragraphs.

3. RESULTS

3.1 Quantitative Impact on Comprehension Performance

Across reviewed empirical trials, cluster technology demonstrated statistically significant positive impacts on L2 reading comprehension. Meta-analytic synthesis of L2 concept mapping research confirms a large overall effect size (Hedges' $g = 1.047$). Controlled pre/post-test studies reveal consistent performance superiorities in experimental mapping groups over controls:

- **Saori (2020):** Experimental mind mapping group achieved significantly higher post-test scores ($M = 71.76$, $SD = 6.55$) than the control group ($M = 60.24$, $SD = 8.06$), $F(1, 31) = 23.55$, $p < .001$, partial eta-squared = .432.

- **Phan Thuy Trang (2017):** Concept mapping produced significantly higher post-test comprehension ($M = 7.65$, $SD = 1.24$) relative to control instruction ($M = 6.40$, $SD = 1.10$), $t(62) = -4.14$, $p < .001$.

- **Khatimah & Rachman (2018):** Mind Mapping produced superior narrative comprehension ($M = 84.00$) compared to Semantic Mapping ($M = 76.97$), with pass rates rising from 56% to 84% across instructional cycles.

3.2 Text-Structure Alignment and Summarization Quality

Empirical research on text-structure fit (Marginingsih et al., 2025) demonstrates that aligning visual organizers with text genres mitigates cognitive friction. As shown in Table 1, students reading cause-and-effect texts scored significantly higher using Cause-Effect T-Charts ($M = 3.67$) compared to Compare-Contrast Venn Diagrams ($M = 3.24$), $t(199) = 6.94$, $p < .001$, $d = 0.56$.

Table 1

Summarization Rubric Scores and Organizer Alignment Effects (N = 200)

Rubric Dimension / Condition	Mean Score (out of 4.0)	Standard Deviation	Statistical Comparison / High Category %
Focus and Main Idea Relevance	3.81	0.74	57.5% High Performance
Content Accuracy & Details	3.72	0.79	57.5% High Performance
Language Structure & Coherence	3.34	0.91	42.0% High Performance
Paraphrasing & Originality	2.98	0.93	35.5% Low Performance

Rubric Dimension / Condition	Mean Score (out of 4.0)	Standard Deviation	Statistical Comparison / High Category %
Cause-Effect T-Chart Alignment	3.67	0.71	$t(199) = 6.94, p < .001, d = 0.56$

Note. Data synthesized from Marginingsih et al. (2025). Lower paraphrasing scores highlight the need for explicit vocabulary scaffolding.

3.3 Digital Systems and Long-Term Information Retention

Digital concept mapping modalities demonstrate substantial advantages for long-term recall. In Kit-Build mapping trials (Andoko et al., 2020), students using KB maps with source connections achieved higher immediate comprehension ($M = 7.87$) and 2-week delayed retention ($M = 7.31$) than KB without source connections (Delayed $M = 6.58$) and summary writing controls (Delayed $M = 6.00$), $F(2, 452) = 22.41, p < .001$. Alkhateeb et al. (2016) similarly reported an 86% delayed recall rate for concept-mapped text vs. 42% for unmapped underlined text ($p < .05$).

4. DISCUSSION

4.1 Cognitive Mechanisms of Visual Offloading

The findings support the premise that cluster technology transforms L2 reading from passive decoding into active spatial-cognitive construction. By externalizing macrostructures into node-link networks, cluster maps reduce extraneous cognitive load. L2 readers avoid holding complex propositions simultaneously in working memory, allowing spatial cartography to facilitate dual-code logogen-imagen integration (Paivio, 1986).

4.2 Structural Fit vs. Cognitive Friction

A key insight is the principle of 'structural fit'. When organizer structures mirror the text's rhetorical organization (e.g., T-charts for causal passages), cognitive friction is minimized. Conversely, forcing a causal text into an ill-fitted structure (like a Venn diagram) introduces extraneous confusion, distracting from core proposition extraction (Marginingsih et al., 2025).

4.3 Bridging the Paraphrasing Gap

Despite high main idea relevance scores ($M = 3.81$), rubric breakdowns reveal a persistent 'paraphrasing gap' ($M = 2.98$). Visual mapping helps L2 students locate main ideas, but does not automatically supply the vocabulary needed for original re-articulation. Educators must pair cluster mapping with explicit linguistic scaffolding, such as synonym substitution and sentence starter banks.

5. Conclusion and Recommendations

Cluster technology is an empirically validated methodology for enhancing L2 reading comprehension, structural text awareness, and long-term retention. Grounding visual cartography in Dual Coding, Schema, and Cognitive Load theories provides L2 readers with vital cognitive scaffolding.

Key Recommendations for Language Educators:

1. Implement the 3-Stage Routine: Combine Pre-Reading brainstorming, While-Reading structural mapping, and Post-Reading summary writing.
2. Match Organizer to Text Genre: Align visual diagrams explicitly with text structures (e.g., T-charts for causal texts).

3. Enforce Node Density Limits: Enforce a 3–5 keyword limit per node to prevent cognitive overload and verbatim copying.

4. Combine Visuals with Language Scaffolding: Pair visual mapping routines with explicit vocabulary substitution drills and sentence frames.

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