

Implementing Electronic Mind-Mapping in the EFL Prewriting Process

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Abstract

Electronic mind mapping, a cognitively mediated visualization method that externalizes idea generation and concept development during the prewriting stage, represents a potentially groundbreaking strategy for improving the planning, organization, and production of complex written assignments. By enabling the organization of ideas, the creation of relational links among concepts, and the deliberate management of metacognitive functions, this technique addresses ongoing difficulties in English as a Foreign Language (EFL) writing instruction. This quasi-experimental research examined the effectiveness of software-assisted mind mapping in enhancing the quality of essays, cognitive involvement, and the affective dimension of writing self-confidence among third-year EFL students ($N = 50$) studying at the University of Oran 2, Algeria. Participants were divided into a structured digital mind-mapping training group ($n = 25$) and a control group ($n = 25$) that used conventional prewriting methods. Extensive mixed-methods data collection included the examination of essay papers, the distribution of a validated 25-item Likert-scale survey, and a systematic classroom observation. The results offer empirical evidence supporting the incorporation of electronic mind mapping into EFL writing courses and indicate that digitally aided scaffolding of the prewriting stage serves as a practical, research-backed strategy for enhancing not only the quality of argumentative writing but also students' metacognitive and emotional attitudes toward writing. However, despite these promising outcomes, the field remains characterized by a paucity of theoretically grounded, empirically validated implementation frameworks for electronic mind mapping across diverse writing genres and stages of the writing process. This investigation thus addresses a critical gap in the EFL writing pedagogy literature. It lays the foundation for future research examining the generalizability, sustainability, and scalability of mind-mapping interventions across diverse linguistic and educational contexts.

Keywords: Cognitive; Educational Contexts; Electronic; English Language; Mind Mapping; Prewriting

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Introduction

Writing in an English-as-a-foreign-language setting presents significant challenges for both teachers and students. The time secondary school teachers devote to teaching writing has been significantly reduced, with the average instructor allocating less time to writing instruction (Drew et al., 2017). Pupils in schools lack a well-structured framework for developing writing skills, leading many to require support with their writing competence at university (Srouf et al., 2021). In the context of teaching English as a Foreign Language, students lack authentic interaction with the language, which necessitates intentional learning and close attention to their English usage (Kaewnuch, 2019). Despite this, numerous English learners struggle to enhance their writing abilities due to challenges with grammar (Chairinkam & Yawiloeng, 2021). A key cause of these difficulties is the lack of opportunities to practice writing both during lessons and in their daily activities. Instead, their learning centers on filling gaps in sentences or correcting verb tenses to conform to grammar rules, posing difficult-to-overcome challenges in teaching English writing.

According to Kim et al. (2021), writing involves cognitive and linguistic skills. Hofmann and Asmundson's (2017) cognitive theory suggests a mental framework that transforms superficial processes into deeper structures, affecting how information is processed. Ongoing cognitive activities, such as interpreting and modifying communication instances, involve revision, which enhances content development (Mlakar, 2022). The strategies writers use for planning, revising, and managing their time are significantly influenced by monitoring and evaluation methods (Davoodifard, 2022), while cognitive responsive control improves writing skills (Luque & Morgan-Short, 2021).

Mind mapping is identified as a strategy to improve writing skills for EFL students by generating structured visual representations of ideas in written form. This cognitive technique aids learning by engaging brain areas that foster creativity and enhance reasoning abilities. Research indicates that mind mapping assists learners in composing texts and improves their general writing competence. Grant and Archer (2019) advocate its use to encourage learning, while Sebit and Yilidiz (2020) highlight significant content enhancement among students who employ mind maps. Unlike traditional note-taking methods, mind maps provide a visual framework that enhances structure and understanding. Previous research highlights the benefits of mind mapping for EFL students across different settings, demonstrating enhanced comprehension and idea organization. Nonetheless, additional research is required regarding its uses at various writing stages, especially in crafting argumentative paragraphs.

Mind mapping arranges information visually, proving particularly helpful during brainstorming and writing stages (Zamari et al., 2012). While traditionally created by hand, current technology supports digital mind maps, improving convenience and ease of modification. Digital mind mapping can engage students and support understanding of complex topics, including literature (Adnan et al., 2012). Programs such as FreeMind and MindMeister can be used on both desktop and mobile platforms. Utilizing colors distinguishes sub-topics, and adding visuals improves memory retention (Budd, 2004). According to Dominic (2014), software enables faster edits than paper methods. Research by Al-Jarf (2009) demonstrated that students using digital mind mapping performed better, fostering creativity and critical thinking.

This study aims to investigate the effectiveness of electronic mind mapping as a prewriting strategy in improving argumentative essay writing performance, students' attitudes toward writing, and cognitive engagement among third-year Algerian EFL students at the University of Oran 2. The paper seeks to answer the following research questions:

1. Does electronic mind mapping improve argumentative essay quality?
2. How does electronic mind mapping influence prewriting cognition and strategy use?
3. How do students perceive electronic mind mapping as a writing technique?

Based on the research questions and the theoretical framework, the following hypotheses are formulated:

1. Electronic mind mapping significantly improves argumentative essay quality (content, organization, vocabulary, grammar, and mechanics) compared to traditional prewriting methods.
2. Electronic mind mapping enhances students' metacognitive skills and strategic planning during the prewriting process.
3. Electronic mind mapping positively influences students' attitudes toward writing, including writing confidence, strategy utility perception, and engagement in the writing process.

1. Writing as a Cognitive Process

The writing process encompasses the interaction between cognitive and linguistic resources (Kim et al., 2021). According to Hofmann and Asmundson (2017), the cognitive hypothesis posits that an infinite cognitive system is present within an organized framework that extends surface-level mechanisms into structural patterns and information processing. The ongoing cognitive activities include decoding and interpreting functions while retaining and modifying occurrences (Mlakar, 2022). Review and oversight tasks help build content and assist students in organizing their writing quickly and effectively. Evaluation methods enhance processes and significantly influence the writer's behavior in terms of time management, planning, monitoring, revising, and assessing difficulty (Davoodifard, 2022). Luque and Morgan-Short (2021) highlight that cognitive responsive regulation supports the improvement of learners' language skills, including writing. A strong understanding of the different linguistic and cognitive mechanisms underlying writing products supports the improvement of organizational skills in the foreign-language context (Michel et al., 2020)

2. Mind Mapping in EFL Writing Classes

Mind maps, also known as concept maps, cognitive maps, or graphic organizers, depict connections among ideas (Svantesson, 1989). Buzan (1993) promotes mind maps as a visual note-taking technique that utilizes a spatial, non-linear layout, capitalizing on the brain's ability for intricate, linked thinking. They consist of frameworks that organize ideas and their relationships, providing a broader view than traditional linear charts (Adnan & Ilias, 2012). This technique aids in developing a comprehensive understanding of topics, enhances memory of written and spoken material, and is beneficial for writing essays, organizing projects, and documenting meetings. Mind mapping uses imagery and colors to boost memory retention, and Buzan advocates it as superior to conventional note-taking methods for supporting both students and educators. Mind mapping helps students organize ideas and perspectives, supports their grasp of concepts and principles from various origins, and encourages creativity by connecting images to ideas rather than relying solely on recall (McGriff, 2007).

Employing mind mapping is suggested as a method to improve the writing proficiency of EFL learners. Mind maps serve as aids that boost second-language writing skills by encouraging an organized thought process reflected in the written work and by visually enhancing reasoning and cognitive growth during writing lessons. Studies indicate that mind maps activate brain functions to generate clear notes, pertinent vocabulary, and support learning organization, assisting learners in developing writing concepts, linking ideas, and grasping writing topics. In particular, mind mapping facilitates procedural text writing by expressing thoughts and boosting thinking. Furthermore, research shows that mind mapping as a preparatory step leads to favorable student feedback and enhanced writing skills, underscoring the importance of language knowledge in cultivating writing competence.

Grant and Archer (2019) suggest that mind maps can enhance growth and recognition across disciplines by employing a collaborative, encouraging, and creative approach. Many students think that mind mapping is crucial for organizing and locating information during early writing tasks, and that individuals who use it demonstrate notable improvements in content and organization relative to those who do not (Sebit & Yilidiz, 2020). Additionally, unlike top-down note-taking and writing methods that might hinder idea linkage, a mind map emerges as a visual thinking tool offering multiple advantages for authors (Pham, 2021). Likewise, numerous students think that mind mapping helps them brainstorm ideas before

writing, start a piece in an organized manner, quickly draft sentences using words from the branches, improve recall, structure information, break down complex ideas, include more relevant details, boost organization and clarity, and increase their productivity by becoming more effective. Therefore, using mind maps provides benefits for writing progress in a second language (Elhawwa, 2022).

Previous studies have emphasized the benefits of mind-mapping techniques for enhancing writing abilities in a second language. Numerous studies exploring the impact of mind mapping on EFL learners' writing have demonstrated that employing mapping strategies enables EFL students to use English vocabulary more readily. Regarding foreign-language writing, findings showed that mind mapping helped EFL students better understand topics, structure their ideas effectively, and systematically categorize their principal points (Nodoushan & Maibodi, 2017). Mind-mapping methods have been applied to improve writing abilities among EFL learners, as demonstrated by Agustina (2020), who observed gains in creativity and focus when instructing writing through mind mapping. The research highlighted four benefits: enhanced memorization, focus on concepts, improved comprehension, and favorable attitudes toward writing. In education, Pribadi and Susilana (2020) found that mind mapping supports the retention and use of knowledge, helping students link ideas from earlier lessons. Raya et al. (2021) utilized flow mind maps in education, resulting in improved writing precision and increased motivation in the pre-writing phase. However, prior studies have primarily documented the benefits of mind mapping in L2 writing development, leaving questions about its efficacy across different writing stages (prewriting, drafting, and post-writing) for EFL students, particularly in crafting argumentative essays.

Getting ready before putting pen to paper enhances writing quality, particularly because writers with different skill levels allocate different amounts of time to planning. According to Scardamalia and Bereiter's study (1985), younger children create plans that resemble lists, which they then refine into unified texts through editing. Mind mapping, beginning with a core concept, effectively generates ideas for various writing styles, including narratives and persuasive essays (Riswanto & Prandika, 2012). Additionally, Adam and Mowers (2007) found that students who used strategic aids during their study sessions retained information 40% better than those who employed conventional learning techniques, emphasizing the benefits of mind maps in writing instruction. Yunus (2016) found that 92% of students engaged in writing responded positively to mind mapping in their writing assignments, viewing it as advantageous for essay composition. Mind mapping supports organizing ideas, generating unique content with relevant examples, and highlighting key points for additional elaboration. This approach effectively facilitates planning and structuring, enhancing students' grasp of their topics. In support of this, Keles (2012) and Bharambe (2012) emphasize that contemporary mind mapping encourages visually engaging concepts, demonstrates logical progression, organizes ideas, and presents them clearly, thereby identifying it as an important development in the writing process.

Mind mapping is an effective technique for visually organizing information, particularly helpful during brainstorming and the initial stages of writing (Zamari et al., 2012). While traditional mind maps were drawn by hand, modern technology enables digital mind maps, enhancing accessibility, convenience, and the ability to save and edit content. Digital mind mapping can engage students and support understanding of complex topics (Adnan et al., 2012). Various software applications, such as FreeMind and MindMeister, are available for brainstorming and presenting ideas and can be used on both desktop and mobile devices. Using colors in mind maps helps distinguish sub-topics and ideas, and adding images and visual components can boost memory retention (Budd, 2004). According to Dominic (2014), software enables learners to edit and rearrange mind maps more quickly and effectively than paper methods. Al-Jarf's (2009) research revealed that students who used digital mind mapping outperformed their peers who did not, fostering creativity and critical thinking. Liu (2011) further supported these results, showing that mind mapping aids students at different writing proficiency levels, particularly those with high proficiency, when provided with personalized space to develop maps. In general, using technology in education enhances learning experiences, especially for today's tech-savvy learners who are keen on mobile learning and mind mapping in ESL writing (Rafidah et al., 2017).

3. Methodology

3.1 Research Design Framework

This research employed a quasi-experimental design featuring a non-equivalent control group, incorporating both pretest and posttest assessments. This design is appropriate for classroom-based educational research when random assignment is unfeasible due to institutional limitations and established class groupings. This design conforms to contemporary best practices in EFL research, as evidenced by several studies in collaborative writing scenarios, where quasi-experimental and mixed-methods approaches predominate in the literature.

3.2 Sampling and Participants

The sample comprised fifty ($n = 50$) third-year EFL students at the University of Oran 2, Algeria, partitioned into two groups ($n = 25$ each). A convenient sampling method was utilized since practical classroom limitations prevented random assignment. Convenience sampling, a nonprobability method, was employed because participants were selected based on their availability and accessibility within existing classroom groups. This approach restricts the generalizability of findings beyond the unique environment. It is commonly accepted in educational research that, due to ethical and logistical constraints, random assignment is precluded. The two groups were established: complete classrooms with comparable demographic characteristics and prior writing instruction. Baseline comparability among groups was confirmed through pretest comparisons, ensuring that any post-intervention differences could be ascribed to the treatment rather than pre-existing differences.

3.3 Data Collection Tools

Essay Evaluation

Inter-rater reliability was assessed using Cohen's Kappa coefficient (κ) to ensure scoring consistency of across raters. A randomly chosen subset of 25 essays, constituting 50% of the overall sample, is evaluated using the analytic rubric. Cohen's Kappa was used because it accounts for chance agreement, providing a more reliable indication of inter-rater reliability than simple percentage agreement. The application of Cohen's Kappa is warranted for this investigation, as it is considered the benchmark for evaluating inter-rater concordance in categorical rating systems.

Attitudes Questionnaire

A 25-item Likert-scale questionnaire was created to assess students' writing confidence, judgments of approach effectiveness, and participation in the writing process. The questionnaire comprised three subscales: (1) Writing Confidence (8 items), (2) Perception of Strategy Utility (9 items), and (3) Engagement in the Writing Process (8 items). Each question was evaluated using a five-point Likert scale, with 1 representing Strongly Disagree and 5 representing Strongly Agree. The instrument's validity was confirmed through expert evaluation by three specialists in EFL teaching and research methodology, along with pilot testing with a comparable cohort of students ($n = 15$) excluded from the primary study to ensure face validity and item clarity. Internal reliability was evaluated using Cronbach's alpha, with values above .90 indicating exceptional reliability.

Classroom Observation

Structured, non-participant observations recorded students' participation, use of writing skills, observable signs of cognitive processing, and reactions to instruction. A procedure for observation was established to document essential activities, such as idea generation, collaborative planning, revision techniques, the use of transitions, and discourse on concepts. The researcher conducted observations during six prewriting sessions (three per group), meticulously documenting field notes that were later categorized for thematic analysis. The observational data were utilized to corroborate the quantitative findings and enhance understanding of the intervention's classroom implementation.

3.4 Data Analysis Tools

Data analysis was performed using SPSS (Statistical Package for the Social Sciences) version 26.0. Descriptive statistics (means and standard deviations) were produced to describe essay scores and attitude questionnaire responses for both groups. To compare pretest and posttest scores on essay writing and attitude dimensions between the experimental and control groups, the independent-samples t-test, a parametric inferential test for determining whether a statistically significant difference exists between two independent groups, was used. Covariance (ANCOVA) was used to compare posttest performance, controlling for pretest scores. This analysis was performed to isolate the intervention's effect, controlling for initial differences. To assess the practical importance of observed differences, effect sizes were estimated using Cohen's d ($d = 0.20$, small; $d = 0.50$, medium; $d = 0.80$, big). Statistical assumptions were checked before using parametric tests. Shapiro-Wilk tests supported the assumption of normality ($p > .05$ for all variables) and Levene's test supported the assumption of homogeneity of variance ($p > .05$), justifying the use of t-tests and ANCOVA.

3.5 Operationalization of Variables

Independent Variable: Electronic mind mapping intervention in the prewriting stage, defined as systematic training and practice in utilizing digital mind-mapping software (MindMeister) to develop persuasive essays

Dependent Variables:

- a. **Argumentative Essay Quality:** Measured using a five-dimensional analytic rubric assessing content, organization, vocabulary, grammar, and mechanics on a 5-point scale.
- b. **Writing Attitudes:** Measured using a 25-item Likert scale questionnaire assessing writing confidence, strategy utility perception, and engagement in the writing process.
- c. **Cognitive Engagement and Strategy Use:** Qualitatively assessed through structured classroom observations documenting planning behaviors, collaboration, and metacognitive strategy application.

Control Variables:

Before writing instruction, grade level, language proficiency level (all participants were third-year EFL students with similar academic proficiency), and experience to conventional prewriting techniques.

3.6 Treatment and Experimental Procedures

The research was carried out over 10 weeks during the second semester of the academic year. The experimental protocols comprised three phases:

Phase One: Pre-test (Week One)

Both groups composed a pretest argumentative essay on a neutral subject ("The role of social media in contemporary communication") without prior prewriting instruction. Essays were evaluated separately by two assessors utilizing the analytic rubric. Both groups also administered the attitudes questionnaire to ascertain baseline perceptions of writing confidence, approach efficacy, and involvement.

Phase 2: Intervention (Weeks 2-9)

The experimental group underwent systematic training in electronic mind mapping utilizing MindMeister software. Training encompassed:

- Week 2: Overview of mind-mapping ideas and features of MindMeister software
- Weeks 3-4: Supervised practice in developing mind maps for ideation and organization
- Weeks 5-6: Implementation of mind mapping for the planning of argumentative essays, encompassing thesis formulation, argument development, and counter-argument preparation.

- Weeks 7-9: Autonomous application of thought mapping for essay organization, accompanied by peer cooperation and teacher evaluation.

The control group received traditional prewriting instruction, including outlining, brainstorming lists, and freewriting activities, with instructional time equivalent to that of the experimental group.

During the intervention, systematic classroom observations were conducted to record students' involvement, strategy use, and cognitive processing behaviors.

Phase 3: Posttest (Week 10)

Both groups produced a posttest argumentative essay on a similar topic ("The impact of artificial intelligence on education") utilizing their designated prewriting techniques. The essays were evaluated separately by the same two raters utilizing the analytic rubric. Both groups completed the attitudes questionnaire to evaluate post-intervention perceptions.

3 Result and Discussion

4.1 Essay Evaluation

Essay evaluation was conducted using a multidimensional analytic rubric that assessed five key aspects of students' writing: content (relevance, depth, and quality of ideas), organization (logical structure, coherence, and transitions), vocabulary (word choice, range, and appropriateness), grammar (grammatical accuracy and sentence structure), and mechanics (spelling, punctuation, and capitalization), each rated on a five-point scale (Table 1).

Table 1: Argumentative Essay Analytic Rubric Dimensions

Dimension	Description	Scale
Content	Relevance, depth, and quality of ideas	1-5
Organization	Logical structure, coherence, and transitions	1-5
Vocabulary	Word choice, range, and appropriateness	1-5
Grammar	Grammatical accuracy and sentence structure	1-5
Mechanics	Spelling, punctuation, and capitalization	1-5

This table specifies the multidimensional analytic rubric used to evaluate argumentative essays, ensuring that both global (content and organization) and local (vocabulary, grammar, mechanics) features are systematically assessed on a standard five-point scale. The definition of each dimension clarifies the construct coverage and supports the validity of subsequent quantitative comparisons between groups.

Table 2: scoring agreement

Cohen's Kappa values validated scoring agreement throughout every rubric criterion:

Cohen's Kappa coefficients indicated almost perfect agreement across all rubric dimensions (average $\kappa = 0.88$; observed agreement = 92%), confirming that essay scores were highly consistent between raters (Table 2). This level of agreement strengthens confidence that observed differences in student performance are attributable to the intervention rather than scoring subjectivity or measurement error.

Dimension	Observed Agreement	Cohen's κ	Interpretation
Content	92.0%	0.886	Almost Perfect
Organization	92.0%	0.890	Almost Perfect
Vocabulary	90.0%	0.853	Almost Perfect
Grammar	94.0%	0.908	Almost Perfect
Mechanics	92.0%	0.864	Almost Perfect
Average	92.0%	0.880	Almost Perfect

The pretest results showed that experimental and control groups were statistically equivalent on all writing dimensions and on the total score (all p-values > .05, negligible to small effect sizes) (Table 3). This baseline equivalence supports the internal validity of the quasi-experimental design by indicating that any posttest differences can reasonably be attributed to the electronic mind-mapping treatment rather than pre-existing disparities.

Table 3: Baseline equivalence table (Pre-test means)

Dimension	Experimental (M $\pm$ SD)	Control (M $\pm$ SD)	t(48)	P
Content	2.48 $\pm$ 0.51	2.52 $\pm$ 0.51	-0.277	.783
Organization	2.48 $\pm$ 0.51	2.52 $\pm$ 0.51	-0.277	.783
Vocabulary	2.52 $\pm$ 0.51	2.60 $\pm$ 0.50	-0.560	.578
Grammar	2.48 $\pm$ 0.51	2.52 $\pm$ 0.51	-0.277	.783
Mechanics	2.96 $\pm$ 0.84	3.12 $\pm$ 0.78	-0.697	.489
Total	12.92 $\pm$ 1.15	13.28 $\pm$ 0.98	-1.190	.240

Posttest Results

Table 4: Post-test results table

Dimension	Experimental (M $\pm$ SD)	Control (M $\pm$ SD)	t(48)	P	Cohen's d
Content	4.28 $\pm$ 0.68	3.12 $\pm$ 0.73	5.839	<.001	1.652 (Large)
Organization	4.56 $\pm$ 0.51	3.00 $\pm$ 0.71	8.967	<.001	2.536 (Large)
Vocabulary	4.00 $\pm$ 0.65	2.92 $\pm$ 0.76	5.418	<.001	1.532 (Large)
Grammar	3.56 $\pm$ 0.51	2.88 $\pm$ 0.78	3.652	<.001	1.033 (Large)
Mechanics	3.84 $\pm$ 0.75	3.44 $\pm$ 0.51	2.218	.031	0.627 (Medium)
Total	20.24 $\pm$ 1.33	15.36 $\pm$ 1.70	11.279	<.001	3.190 (Large)

The posttest findings revealed that the experimental group significantly outperformed the control group on every dimension of writing quality, with large effect sizes for content, organization, vocabulary, grammar, and the total score, and a medium effect for mechanics (Table 4). The robust gains in organization ($d \approx 2.54$) and content ($d \approx 1.65$) suggest that electronic mind mapping is especially effective for helping learners structure their arguments and elaborate ideas in argumentative essays. These findings provide strong support for the first hypothesis, indicating that electronic mind mapping significantly improves argumentative essay quality compared to traditional prewriting methods.

Table 5: Gain Score Analysis

Dimension	Experimental Gain	Control Gain	Advantage
Content	+1.80 (73%)	+0.60 (24%)	200%
Organization	+2.08 (84%)	+0.48 (19%)	333%
Vocabulary	+1.48 (59%)	+0.32 (12%)	363%
Grammar	+1.08 (44%)	+0.36 (14%)	200%
Mechanics	+0.88 (30%)	+0.32 (10%)	175%
Total	+7.32 (57%)	+2.08 (16%)	252%

The gain score analysis highlights that students using electronic mind mapping achieved markedly greater improvements than those in the control group across all dimensions, with relative advantages ranging from 175% to 363%. The experimental group's total score gain of +7.32 points (57% improvement) compared to +2.08 points (16% improvement) in the control group underscores the substantial practical impact of the intervention on overall writing development.

ANCOVA Results

The ANCOVA results, which statistically controlled for pretest performance, confirmed that group membership (experimental vs. control) had a robust, significant effect on posttest scores across all writing dimensions (Table 6). Large partial eta-squared values, especially for organization ($\eta^2 = .631$) and total score ($\eta^2 = .719$), indicate that electronic mind mapping explains a substantial proportion of variance in writing outcomes beyond initial ability levels, reinforcing the strength and stability of the treatment effect. These findings corroborate the independent-samples t-test results and further substantiate the first hypothesis, demonstrating that the intervention effect persists even when controlling for baseline writing proficiency.

Table 6: The Analysis of Covariance (ANCOVA)

Dimension	Exp. Adj. M	Ctrl. Adj. M	F(1,47)	p	Partial η^2
Content	4.27	3.13	34.40	<.001	.423 (Large)
Organization	4.56	3.00	80.35	<.001	.631 (Large)
Vocabulary	4.00	2.92	28.63	<.001	.379 (Large)
Grammar	3.57	2.87	15.00	<.001	.242 (Large)
Mechanics	3.83	3.45	4.44	.040	.086 (Medium)
Total	20.23	15.37	120.00	<.001	.719 (Large)

The converging evidence from independent-samples t-tests and ANCOVA analyses demonstrates that electronic mind mapping is highly effective in improving argumentative essay writing among Algerian EFL students. The intervention produced large effect sizes ($d = 1.03$ - 3.19) across all writing dimensions, with organization benefiting most prominently ($d = 2.54$, $\eta^2 = .631$). The consistency of findings across both analytical approaches, combined with excellent inter-rater reliability ($\kappa = 0.88$), confirms the robustness

and validity of the observed treatment effects. These results provide strong empirical support for integrating electronic mind-mapping tools into EFL writing curricula, particularly for argumentative essay instruction.

4.2 Attitude Questionnaire

a. Reliability Analysis

All three scales demonstrated excellent internal consistency ($\alpha > .90$) in both groups, confirming that the questionnaire is a highly reliable measurement instrument (Table 7). These values exceed the commonly accepted threshold of .70 for acceptable reliability and .90 for excellent reliability, supporting the use of composite scale scores in subsequent analyses.

Table 7: Reliability Statistics

Scale	Experimental α	Control α	Interpretation
Writing Confidence	.969	.927	Excellent
Strategy Utility Perception	.990	.972	Excellent
Engagement in Writing Process	.959	.920	Excellent

Table 8: Descriptive Statistics by Group

Scale	Exp. M	Exp. SD	Ctrl. M	Ctrl. SD	Difference
Writing Confidence	4.33	0.42	2.82	0.50	1.51
Strategy Utility Perception	4.07	0.42	3.23	0.40	0.84
Engagement in Writing Process	4.20	0.35	3.15	0.32	1.05

The experimental group shows consistently higher mean scores across all three attitude dimensions, with differences ranging from 0.84 to 1.51 points on the 5-point Likert scale. The experimental group's means fall in the "Agree–Strongly Agree" range (4.07–4.33), while the control group's means cluster in the "Neutral–Agree" range (2.82–3.23), indicating substantially more positive attitudes among students who used electronic mind mapping.

Table 9: Independent-Samples T-Test Results

Scale	t(48)	p-value	Cohen's d	Effect Size
Writing Confidence	11.48	<.001	3.25	Very Large
Strategy Utility Perception	7.26	<.001	2.06	Very Large
Engagement in Writing Process	11.16	<.001	3.16	Very Large

Significance levels: $p < .001$

All three comparisons reveal highly significant differences ($p < .001$) with very large effect sizes ($d > 2.0$). Cohen's d values of 3.25, 2.06, and 3.16 far exceed the conventional threshold for a large effect ($d = 0.80$), indicating that the electronic mind mapping intervention had not only statistically significant but also educationally powerful impacts on students' attitudes toward argumentative writing.

Table 10: Writing Confidence Items

Description	Exp. M	Ctrl. M	t(48)	D
Feel confident writing argumentative essays	4.40	2.76	12.36	3.50
Can clearly express ideas	4.40	2.60	12.73	3.60
Able to organize arguments logically	4.40	2.60	12.73	3.60
Feel confident starting essay after planning	4.40	2.60	12.73	3.60
Believe can improve with effort	4.20	3.60	4.65	1.31
Not afraid of making mistakes	4.20	2.40	9.86	2.79
Feel confident revising draft	4.40	3.20	5.37	1.52
Feel capable without constant teacher help	4.20	2.80	12.12	3.43

The largest effects appear on items related to core argumentative writing skills: expressing ideas clearly, organizing arguments logically, and starting essays after planning, all with $d \approx 3.60$. This pattern suggests that electronic mind mapping particularly strengthens students' confidence in structuring and articulating their arguments—the very skills that mind mapping is theoretically designed to support.

Table 11: Strategy Utility Perception Items

Description	Exp. M	Ctrl. M	t(48)	D
Pre-writing strategies help write better	4.20	3.60	4.65	1.31
Mind mapping helps generate ideas	4.20	3.20	8.66	2.45
Helps see thesis-argument relationship	4.20	3.20	8.66	2.45
Helps organize details and examples	4.20	3.20	8.66	2.45
Helps plan counter-arguments	4.20	3.20	8.66	2.45
Helps connect essay parts	4.20	3.20	8.66	2.45
Saves time when preparing essays	4.20	3.20	8.66	2.45
More useful than traditional methods	3.04	3.04	0.00	0.00
Would like to use in other tasks	4.20	3.20	8.66	2.45

Most items show very large effects ($d \approx 2.45$), indicating that experimental-group students strongly perceive mind mapping as helpful for generating ideas, structuring arguments, planning counter-arguments, and connecting essay components. However, comparing mind mapping to traditional methods shows no difference ($d = 0.00$; both groups $M = 3.04$), suggesting that students' perceived benefits emerge more clearly in concrete applications than in abstract preference judgments. This neutral response may reflect limited exposure to mind mapping in the control group or a tendency not to make blanket comparisons when direct experience is absent.

Table 12: Engagement in Writing Process Items

Description	Exp. M	Ctrl. M	t(48)	D
Feel interested and motivated	4.20	3.20	8.66	2.45
Enjoy using electronic tools	4.00	3.00	∞	∞
Pay more attention when using mind mapping	4.20	2.80	12.12	3.43
Work actively with classmates	4.20	3.20	8.66	2.45
Willing to spend extra time planning	4.20	3.20	8.66	2.45
Feel more involved in writing process	4.20	3.20	8.66	2.45
More likely to revise plan after mapping	4.40	3.40	7.07	2.00
Positive attitude toward mind mapping	4.20	3.20	8.66	2.45

The largest effect appears on paying attention when using mind mapping, with $d = 3.43$, indicating that the intervention strongly increased students' focus during pre-writing activities. Very large effects also appear on items related to motivation, collaboration, willingness to invest effort in planning, and feeling involved in the writing process. These patterns suggest that electronic mind mapping makes the pre-writing phase more engaging, interactive, and cognitively stimulating.

4.3 Analysis of observation findings

Engagement and Motivation

Students in the experimental group (employing electronic mind mapping) showed notably greater on-task and motivated behaviors than those in the control group. On average, students in the experimental group were assessed as being more frequently focused during prewriting periods, with the majority actively creating, modifying, and presenting map-based plans. Control group students, relying on traditional strategies such as outlining or freewriting, demonstrated moderate participation but slightly lower levels of volunteering and collaboration. Their engagement ratings occasionally dipped during longer planning segments, especially when tasks were less structured.

Mind Mapping Use and Planning Practices

Table 13 summarizes the observed differences in planning practices between the two groups. Students in the experimental group generated ideas collaboratively more frequently, developed well-connected visual representations of their arguments, planned counterarguments more often, revised their prewriting plans more dynamically, used transitions more explicitly, and discussed ideas with peers more actively than the control group.

Table 13: Mind mapping use and planning practices

Indicator	Control group	Experiment group
Generate ideas collaboratively	Sometimes	Frequently
Organize supportive form	Limited, linear format	Well developed visual connections
Plan counter argument	Occasionally	Often; visible in mind maps
Revise prewriting plans	Rarely; few changes	Frequently; rearranges map branches
Use transitions	Implicit; less marked	Explicit; noted on mind map
Discussing ideas before writing	Sometimes with peers	Frequently; peer support evident

Cognitive Processing and Adjustment

Students in the experimental group demonstrated greater cognitive involvement, including discussing concepts aloud, refining organizational components, and modifying written outlines before drafting. They could distinctly recognize connections among the thesis, arguments and supporting evidence. The control group's planning was less dynamic and often relied on linear structures with fewer visible connections between essay components.

Key Challenges

Each group faced challenges: students frequently required assistance with using software functions, and control students occasionally struggled without clear structures to manage complex arguments.

Over the course of the observations, participants in the experimental group adapted quickly, showing increasingly independent planning and strategic thinking.

Overall Lesson Impression

The researcher consistently rated experimental group sessions as demonstrating higher engagement and organizational quality. The use of electronic mind mapping not only improved group collaboration and cognitive processing but also yielded more coherent, connected essay plans than traditional methods.

4 Discussion of the findings

The study uses both qualitative and quantitative data to answer the three research questions and to test the accompanying hypotheses.

Does electronic mind mapping improve the quality of argumentative essays?

The answer is an emphatic yes. The experimental group considerably outperformed the control group in all five aspects of essay quality, with effect sizes ranging from $d = 0.63$ to 2.54 and an overall effect size of $d = 3.19$. The notably strong results on organization and content show that electronic mind mapping facilitates higher-order cognitive processes such as idea production, argument structuring, and logical coherence, rather than simply increasing surface-level linguistic accuracy. The ANCOVA analyses, controlling for baseline proficiency, further supported these performance improvements, confirming the intervention's impact even in the face of pre-existing inequalities. Thus, hypothesis 1 is well supported: electronic mind mapping greatly increases the quality of argumentative essays compared to traditional prewriting techniques.

How does electronic mind mapping influence prewriting cognition and strategy use?

Observations indicated that students in the experimental group engaged in qualitatively different, more complex prewriting activities than those in the control group. They were more collaborative in generating ideas, developed more well-connected visual representations of thesis-argument-evidence relationships, planned counterarguments more often, revised their prewriting plans dynamically rather than treating them as fixed, used transitions more explicitly, and discussed ideas with peers more actively. The students were not only brainstorming but purposefully organizing, monitoring, and refining their thinking in ways consistent with effective writing processes described in cognitive models of composition (Hofmann &

Asmundson, 2017; Mlakar, 2022). These behaviors indicate increased metacognitive awareness and strategic planning. In contrast, planning in the control group was more linear and sequential and less integrated. Thus, Hypothesis 2 is fully supported: the use of electronic mind mapping boosts students' metacognitive skills and strategic planning in the prewriting process.

How do students perceive electronic mind mapping as a writing technique?

The results of the attitude survey showed that the experimental group students expressed significantly greater favorable perceptions in all three dimensions: writing confidence ($d = 3.25$), approach utility perception ($d = 2.06$), and engagement in the writing process ($d = 3.16$). The largest effects were found on items most closely related to core argumentative writing skills: clarity of ideas, logical organization of arguments and feeling confident to start essays after planning. These findings suggest that electronic mind mapping improved students' self-efficacy in exactly those areas that it sought to support. In addition, students stated that mind mapping helped them to generate ideas, organize arguments, develop counter-arguments, connect different parts of the essay, and save time. The intervention improved engagement, interaction, and cognitive stimulation during the prewriting period, showing strong impacts on motivation, attention, collaboration, and readiness to invest effort in planning. Thus, Hypothesis 3 is substantially supported: electronic mind mapping positively affects students' attitudes about writing, including their confidence in writing, perceptions of the value of strategies, and their participation in the writing process.

This great congruence across these three data sources, essay performance, student perceptions, and observed classroom behaviors, significantly strengthens the validity and instructional meaning of these findings. The findings extend past studies on mind mapping in EFL writing (Grant & Archer, 2019; Sebit & Yilidiz, 2020; Elhawwa, 2022) by providing empirical support for electronic mind mapping in argumentative essay writing, a genre that requires advanced cognitive and rhetorical skills. The current study operationalizes and measures the effects of mind mapping on multiple dimensions, including cognitive (metacognitive strategy use), affective (confidence and motivation) and product (essay quality), thus providing a more comprehensive account of how digital scaffolding in prewriting supports EFL learners than previous studies that have documented general benefits of mind mapping.

Furthermore, the findings are consistent with cognitive theories of writing (Hofmann & Asmundson, 2017; Kim et al., 2021), which propose that successful composition is a function of the interaction between cognitive and linguistic resources. The externalization of thought processes for planning through electronic mind mapping seems to reduce cognitive load, allowing students to organize ideas, establish relational links between concepts, and intentionally control metacognitive functions, which are, in fact, the processes that differentiate skilled from novice writers. The very substantial effect sizes for organization ($d = 2.54$) and content ($d = 1.65$) provide support for the theoretical notion that mind mapping supports higher-order planning and idea formation, and not only surface-level correctness.

The results provide strong empirical support for the inclusion of electronic mind-mapping tools in the EFL writing curriculum, especially in the teaching of argumentative essays. The intervention enhanced not only what students produced but also how they approached, managed and interacted with the complex cognitive demands of academic writing. Electronic mind mapping is a motivating and effective prewriting strategy. It is of great pedagogical value in both the cognitive and affective dimensions of writing development for third-year EFL students at the University of Oran 2. It is likely to be similarly valuable in similar contexts where students lack structured frameworks for developing writing skills.

Conclusion

The research provided strong empirical evidence that using electronic mind mapping in the prewriting phase leads to a significant improvement in the quality of students' argumentative essays, a more positive attitude towards writing, and a greater depth of cognitive engagement compared to traditional prewriting. The experimental group improved significantly in all aspects of writing: content, organization, vocabulary, grammar and mechanics. Classroom observation indicated that mind mapping encouraged collaborative idea generation, continuous plan revision, explicit attention to transitions, and visible connections among the thesis, arguments, and evidence, suggesting improved metacognitive and strategic planning skills.

The results support all three research hypotheses, showing that electronic mind mapping is an effective, research-based technique for improving not only the quality of argumentative writing but also students' metacognitive skills and emotional attitudes towards writing.

The results have substantial pedagogical implications for EFL writing education. Electronic mind mapping should be incorporated into the writing curriculum as a regular prewriting method, especially for argumentative essays, where organizational coherence and idea elaboration are critical. Teacher training programs should include training on digital mind-mapping tools and their pedagogical uses, and curriculum planners should allow ample time for students to learn and practice mind mapping before they use it on their own. Moreover, educational institutions should purchase easy-to-use mind-mapping software and provide students with the technological means to interact effectively with digital tools.

Although the results are promising, we note several limitations:

1. The use of convenience sampling limits the generalizability of findings to contexts other than the specific setting of third-year EFL students at the University of Oran 2. A future study using random assignment or larger, more diverse groups might increase external validity.

2. The intervention was delivered over 10 weeks, and immediate posttest effects were investigated. Little is known about the long-term retention and sustainability of mind-mapping skills and their lasting effects on writing quality.

3. The study was conducted in one institutional setting with a particular linguistic and educational environment (Algerian EFL learners). The efficiency of electronic mind mapping could vary in different cultural, linguistic and educational environments.

4. The study confined itself to argumentative writings. The effectiveness of mind mapping across other types of writing (e.g., narrative, expository, descriptive) and in different phases of writing (drafting, revision) has yet to be researched.

Taking the findings and limitations of this study into account, we propose the following research directions:

1. Conduct longitudinal research over several semesters or academic years to explore the long-term impacts of electronic mind mapping on writing development, strategy transfer, and sustained attitude change.

2. Investigate the usefulness of electronic mind mapping in several genres of writing (narrative, expository, descriptive, and persuasive) and phases of writing (drafting, revision, and editing) to develop a holistic view of its instructional application.

3. Investigate the usefulness of electronic mind mapping in different linguistic and educational settings, in order to evaluate their generalizability and cultural appropriateness.

4. Investigate the usefulness of several digital mind mapping tools (e.g., MindMeister, Coggle, FreeMind) to determine the best software features and pedagogical affordances.

Despite these limitations, the field still needs theoretically based, empirically proven implementation frameworks for electronic mind mapping across different writing genres and stages of the writing process. This study fills an important gap in the literature on EFL writing pedagogy. It provides a basis for future research investigating the generalizability, sustainability and scalability of mind-mapping interventions across other languages and educational contexts. In conclusion, the results provide robust pedagogical

support for integrating electronic mind mapping into EFL writing curricula to improve student achievement, develop metacognition, and boost attitudes towards writing.

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