



Digital mind mapping as a pedagogical scaffolding: Enhancing argumentative writing in secondary classrooms through technology-supported instruction

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Abstract

As secondary classrooms increasingly adopt digitally supported pedagogies, understanding how technology can scaffold writing development is essential for sustainable and learner-centered instruction. This study examined the use of digital mind mapping using MindMeister in enhancing the organization and coherence of argumentative essays among Grade 12 students. The study employed a one-group pretest - posttest design with mixed methods to examine both quantitative and qualitative outcomes. Fourteen students participated in a four-week intervention in which digital mind mapping was integrated as a structured pre-writing strategy. Quantitative data were collected through pretest and posttest essay scores and analyzed using descriptive statistics and effect size (Cohen's *d*). The result indicated a significant improvement in students' writing performance, supported by a substantial effect size. Qualitative data from semi-structured interviews and the research diary revealed improvements in thesis development, logical sequencing of ideas, argument construction, and overall coherence. Students also reported increased confidence, focus, and engagement. The findings position digital mind mapping as a form of digitally mediated pedagogical scaffolding that supports structured and student-centered learning. The study highlights its potential as a sustainable and scalable approach to technology-supported writing instruction in secondary education. Despite limitations, the study contributes to research on digital pedagogy and writing development.

Keywords: Academic performance; Argumentative essay; Digital mind mapping; Organization and coherence; Writing confidence

1. Introduction

Bhutan's modern education system is evolving, adapting to global trends, prioritizing critical thinking, creativity, communication, and collaboration. Grounded in the philosophy of Gross National Happiness (GNH), Bhutan's education system aims to nurture individuals who are not only intellectually capable but also emotionally aware and socially accountable. Incorporating the Bhutan Baccalaureate framework and competency-based learning places increasing importance on fostering higher-order thinking skills in students, especially at the secondary and higher secondary levels.

As both the medium of instruction and a fundamental subject, English is crucial in developing students' academic achievements and communication skills. Essay writing, particularly argumentative essays, is an essential part of the English curriculum that requires students to think critically, construct logical arguments, and convey their opinions. Despite this, many grade 12 students find it challenging to craft well-structured argumentative essays. Frequent obstacles included unclear idea presentation, ineffective thesis statements, weak transitions between paragraphs, and failure to support arguments with appropriate evidence.

These challenges stem from various factors, including inadequate planning strategies, minimal exposure to structured writing frameworks, and a lack of confidence in expressing ideas. As a result, students often perceive argumentative writing as complex and uninteresting, which negatively impacts their overall writing skills and academic achievement. Research suggests that visual techniques such as mind mapping can support idea generation and improve coherence in writing by helping learners organize and connect their ideas thoughts more effectively (Al-Jarf, 2009).

With the increasing integration of digital technologies in education, there is a growing need to examine how technology-supported pedagogies can enhance essential academic skills such as writing. Digital tools are not merely instructional aids; they can function as cognitive scaffolds that support learners in organizing, constructing, and refining their ideas. In this context, digital mind mapping tools provide centered and structured writing development in secondary classrooms.

Acknowledging these challenges, this study adopted a quasi-experimental classroom-based design to investigate the effectiveness of mind mapping using MindMeister as a technology-supported strategy for improving Grade 12 students' argumentative essay writing skills. Mind mapping, when implemented through a digital platform, enables learners to visually organize their thoughts, generate ideas, and create logical connections, offering a practical and student-friendly approach to enhancing the structure and clarity in their writing.

This study therefore explores whether integrating digital mind mapping into the essay planning process can help students in developing clearer arguments, improving organization, and enhancing confidence in argumentative writing, while also contributing to more sustainable and structured writing practices in secondary education.

2. Literature Review

2.1. Minding Mapping Writing Organisation

Mind mapping has been widely recognized as an effective strategy for enhancing students' writing skills, particularly in organizing ideas and improving coherence. Research indicates that mind mapping supports learners in structuring their thoughts, generating ideas, and developing logical connections between concepts. For instance, Al-Zyoud et al. (2017) highlights its role in organizing thoughts, structuring ideas, and improving writing fluency and clarity, particularly in descriptive writing while, Al-Jarf (2009) found that mind maps significantly enhanced essay organization and idea generation in argumentative writing. Similarly, Buzan and Buzan (2010) emphasize that mind mapping stimulates both brain hemispheres, promoting creativity and critical thinking essential for strong essay construction.

These findings are further supported by Davies (2011), who adds that while concept and argument mapping focus on logical relationships, mind mapping is particularly effective in fostering creativity and flexible thinking during the writing process. Empirical studies by Farrand et al. (2002); Nesbit and Adesope (2006) also demonstrate that mind mapping improves memory, organization, comprehension, and critical thinking, all of which contribute to stronger academic writing. More recent study by Lalo Daeng and Enre (2024) found that students who used mind mapping outperformed those taught through traditional methods in argumentative essay writing, while also showing engagement and positive attitudes towards learning.

2.2. Digital Mind Mapping and Cognitive Support

With advancements in educational technology, mind mapping has evolved from traditional paper-based strategy to a dynamic digital tool that enhances cognitive engagement. Digital mind mapping platforms provide learners with opportunities to visually organize, modify, and expand their ideas in ways that are not easily achievable through conventional methods. Digital mind mapping can support more effective essay planning by helping students organize ideas before writing, which may improve the organization and coherence of their written texts (Altamimi, 2026; Sebit & Yıldız, 2020). When implemented digitally, these benefits are further amplified through features such as easy reorganization, visual clarity, and the ability to continuously refine ideas.

Digital mind mapping tools also support deeper cognitive processing by allowing learners to manipulate and connect ideas dynamically. Davies (2011) suggests that such tools promote higher-order thinking by enabling students to engage in iterative planning and revision. Similarly, Mento et al. (1999) reports that technology-supported mind mapping enhances critical thinking and improves the logical structuring of written work. These findings indicate that digital mind mapping not only supports idea organization but also facilitates a more interactive and reflective approach to writing.

2.3. Digital Pedagogy and Technology- Supported Writing Instruction

The increasing integration of technologies in education has led to a growing emphasis on digital pedagogy, where technology is used to create interactive, learner-centered environments rather than simply deliver content. In this context of writing instruction, technology-supported approaches provide new opportunities for students to engage actively in the planning and development of their ideas.

Digital tools function as cognitive scaffolds, helping learners break down complex tasks such as argumentative writing into manageable components. Unlike traditional approaches, digital platforms allow students to revise, reorganize, and expand their ideas continuously, supporting iterative learning and reducing cognitive load. This aligns with constructive principles, where learners actively construct knowledge through interaction and reflection.

Importantly, technology-supported writing instruction also contributes to sustainable learning practices. Digital mind mapping provides a reusable and transferable framework that students can apply across subjects and contexts, supporting long-term academic development. Furthermore, its accessibility and adaptability suggest strong potential for scalable implementation in secondary education, particularly in digitally equipped classrooms.

2.4. Writing Development in the Bhutanese Context

Within the Bhutanese education context, mind mapping has shown promising results in improving students' writing skills. Wangmo (2018) investigated its impact on Grade Four students' descriptive writing and reported significant improvement in writing performance, along with increased motivation and confidence. Similarly, Wangmo (2022) explored the use of digital mind mapping among undergraduate students and found that it enhanced reading comprehension and summary writing by enabling better organization of ideas and deeper critical thinking.

These studies demonstrate the applicability of mind mapping across different educational levels in Bhutan. However, this remains limited research focusing specifically on the use of digital mind mapping for argumentative writing in secondary classrooms, particularly in relation to structured writing development and student-centered learning.

2.5. Research Gap

While existing literature highlights the effectiveness of mind mapping and digital mind mapping can function as a pedagogical scaffold for argumentative writing in Bhutanese secondary school. In particular, limited attention has been given to how digital tools can support sustainable, structured and learner centered writing practices.

This study seeks to address this gap by investigating the use of MindMeister as a technology-supported planning tool to enhance the organization and coherence of argumentative essays among Grade 12 students, while also contributing broader discussions on digital pedagogy and writing instruction.

This study aims to answer the following research question:

RQ) How can I enhance argumentative essay writing using mind mapping in grade 12 English?

3. Methodology

3.1. Research Design

This study employed a quasi-experimental classroom-based design to investigate the effectiveness of digital mind mapping in enhancing student' argumentative writing skills. This design allowed the research to systematically assess changes in students' writing performance prior to and following the intervention. In addition, qualitative insight was incorporated to provide a deeper understanding of students' experiences throughout the process. A mixed-methods approach was utilized to ensure a more holistic and comprehensive examination of both learning outcomes and learners' perceptions.

3.2. Participants

The participants of this study comprised 14 grade 12 arts students of Jakar HSS. The group exhibited notable difficulties in organizing and structuring argumentative essays, making them a particularly relevant sample for the purposes of this investigation. All the 14 students participated in both the pretest and posttest assessments.

For the qualitative component of the study, eight students were purposively selected to take part in small-structured interviews. Selection was guided by variation in writing performance and levels of engagement observed during the intervention, ensuring that a diverse range of perspectives was captured and represented in the findings. The sample size of eight participants was considered sufficient, as data saturation was reached, with no substantially new themes emerging from additional responses.

3.3. Quantitative Data Collection and Analysis

3.1.1. Pre-test and post-test

Students completed an argumentative essay as a pre-test to establish a baseline for their writing performance. The assessment specifically focused on two primary variables: organization and coherence, as these were identified as recurring areas of difficulty in students' written work:

Organization refers to the logical arrangement of ideas, including a clear thesis statement, structured paragraphs, and logical sequencing of arguments. Coherence refers to the clarity and flow of ideas, supported by effective transitions and meaningful connections between sentences and paragraphs.

Although additional elements such as argument development, critical thinking, and vocabulary contribute to overall writing quality, this study primarily targeted organization and coherence because they were directly influenced by the essay planning process supported through digital mind mapping.

Following the implementation of the digital mind mapping intervention, students completed a post-test essay to evaluate any improvement in these identified dimensions. The data collected was analyzed using descriptive. Mean scores and standard deviations were calculated to summarize students' performance in the pre-test and post-test. Additionally, Cohen's *d* was used to measure the effect size, providing insight into the practical significance of the intervention despite the small sample size of 14 students.

3.1.2. The survey questionnaire

A survey questionnaire, a five-point Likert Scale, helped examine students' perceptions of argumentative essay writing through mind mapping. The data collected through the survey questionnaire were analyzed using descriptive statistics such as mean and standard deviation.

3.1.3. Qualitative data collection and analysis

To complement the quantitative findings, qualitative data were collected to gain deeper insight into students, learning experiences and strengthening the triangulation of results. Semi-structured interviews were conducted with eight purposively selected students after the intervention to explore their perceptions of digital mind mapping and its role in improving the organization and coherence of their argumentative essays.

The data was analyzed using thematic analysis as proposed by Braun and Clarke (2006), involving familiarization with the data, coding, identifying patterns, and developing themes to capture key insights into students' cognitive engagement and writing development.

Additionally, document analysis was employed to examine students' pre-test and post-test essays for qualitative evidence of improvement in argumentative elements such as thesis clarity, logical, sequencing, paragraph unity, and transitions.

Students' digital mind maps were analyzed to understand how ideas are generated, organized, and connected during the planning process, providing further insight into how digital mind mapping supports structured argument development.

Furthermore, the researchers maintained a research diary throughout the study, from its commencement to its completion. The research diary functioned as a reflective instrument that allowed the researchers to systematically document the research process, reflect on the challenges encountered during the implementation, and capture the improvements and outcomes that emerged during the study.

3.4. Validity and Reliability

Several measures were implemented to ensure the validity and reliability of the research instruments. Three senior English teachers and co-researcher reviewed the pretest and the post-test essay prompts to establish face and content validity, ensuring alignment with the study's objective of assessing organization and coherence in argumentative writing.

To maintain reliability between the pre-test and post-test, students were given comparable argumentative prompts of similar difficulty rather than identical questions. Using the same prompts introduced a practice effect, where students improved due to familiarity rather than intervention.

Comparable prompts helped ensure that any observed improvement was more likely attributable to digital mind mapping strategy. Uniform testing conditions were maintained for both assessments, including the same time allocation, instructions, and classroom environment, to minimize external influences. An analytic rubric was used consistently to evaluate both essays, and discrepancies were discussed to reach consensus. The survey questionnaire was pilot-tested, and its internal consistency was examined using pilot testing to ensure clarity and effectiveness in eliciting meaningful responses. Collectively, these measures strengthened the internal validity and trustworthiness of the study.

3.5. Intervention

The intervention was conducted over four weeks in August, aimed to improve argumentative essay writing skills among Class 12 Arts (14 students) at Jakar Higher Secondary School by implementing mind digital mapping techniques. During the initial week, students were introduced to the structure of argumentative essays and the concept of digital mind mapping, utilizing digital methods. A baseline essay task was assigned to evaluate their writing capabilities, especially in organization and coherence. The second week included guided practice, where students collaborated in groups to develop mind maps on assigned topics and utilized them to draft essays with teacher oversight.

In the third week, students independently created their digital mind maps and wrote essays, followed by peer review sessions where they were provided feedback to each other based on a structured rubric. The final week featured a post-intervention writing task to assess their progress, along with a reflection session where students shared their experiences regarding the use of mind mapping and its impact on their writing. The intervention leveraged the school's digital infrastructure, which included a smart TV and computer labs, enabling students to access mind mapping tools both during and outside of class, thus reinforcing their learning and promoting independent practice.

3.6. Ethical Considerations

To uphold ethical research standards, this study followed the principles of confidentiality and informed consent. Necessary approvals were obtained from the Dzongkhag Educational Office (Bumthang) and the administration of the participating school. Participants were fully informed about the study's objectives, the types of data collected, and their rights regarding the use of their data. Written consent was obtained before the commencement of data collection. As the study was conducted within the context of normal classroom teaching, the intervention formed part of regular learning activities, and participation in the lessons could not be separated from classroom attendance. However, students' individual responses and data remained confidential, and no identifying information was disclosed.

3. Findings

3.1. Findings Based on Quantitative Data

Table 1 presents a comparative analysis of students' performance in argumentative writing before and after the implementation of digital mind mapping as a pedagogical scaffolding strategy.

Table 1

Analysis based on Posttest and Pretest Scores

Test	Mean	Differences in mean	SD	Minimum	Maximum	Effect Size (Cohen's <i>d</i>)
Posttest	71.7	24	5.9	63.5	85.9	0.8
Pretest	47.7		6.5	32.9	57.6	

The results indicate a substantial increase in the mean scores from the pretest ($M = 47.7$, $SD = 6.5$) to the posttest ($M = 71.7$, $SD = 5.9$), with a mean difference of 24 points. This notable improvement suggests that the integration of technology-supported digital mind mapping had a significant positive impact on students' argumentative writing skills.

In terms of score variability, the standard deviation decreased from 6.5 in the pretest to 5.9 in the posttest, indicating a slight reduction in the dispersion of scores. This suggests that students' performance becomes more consistent following the intervention. Furthermore, the range of scores shifted considerably. The pretest scores ranged from 32.9 to 57.6, whereas the posttest scores ranged from 63.5 to 85.9. This upward shift demonstrates that all students, including those with initially lower performance levels, showed marked improvement after the intervention.

Moreover, the effect size, as measured by Cohen's d ($d = 0.8$), indicates a large effect, suggesting that the intervention had a strong and practically significant impact on students' writing performance.

Table 2

Percentile Analysis based on Posttest and Pretest Scores

Test	25th	50th	75th
Posttest	69.4	70.6	71.5
Pretest	44.1	48.0	50.9

The percentile distribution further reinforces this trend. The 25th percentile increased from 44.1 in the pretest to 69.4 in the posttest, the median (50th percentile) rose from 48.0 to 70.6, and the 75th percentile improved from 50.9 to 71.5. These findings indicate that the improvement was consistent across different performance levels, benefiting lower, average, and higher-achieving students alike.

Overall, the findings provide strong empirical evidence that digital mind mapping, when used as a pedagogical scaffolding tool, effectively enhances students' argumentative writing skills in technology-supported secondary classroom settings.

3.2. Students' Perception towards Digital Mind mapping

A descriptive statistical analysis was employed to investigate students' perceptions of digital mind mapping as a tool in argumentative essay writing. The findings revealed consistently positive perceptions across several dimensions, notably interest, motivation, and confidence.

Mean scores across all items ranged from 3.43 to 4.71, reflecting a generally favorable attitude towards digital mind mapping as a pre-writing and planning strategy. Notably, higher mean scores were recorded in dimensions related to learner engagement and idea organization, suggesting that students perceived the tool as effective in facilitating structural thinking and enhancing the overall clarity of their writing arguments.

Furthermore, students' indication of digital mind mapping contributed to a more approachable approach and less daunting experience in argumentative writing tasks. Collectively, these findings suggest that students viewed digital mind mapping as a valuable and supportive instructional

strategy with the potential to enrich their writing process.

Table 3

Confidence in Argumentative Essay Writing

Items	Indicators	Mean	SD	Level of perception
1	I feel confident in writing argumentative essays.	3.57	0.65	High
2	I can effectively organize my thoughts before writing an essay.	3.57	0.76	High
3	I am able to generate strong arguments and counterarguments.	3.43	0.76	Moderate
4	I understand how to structure an argumentative essay properly.	3.79	0.98	High
5	I enjoy writing argumentative essays.	4.43	0.65	High

In terms of specific indicators, students expressed confidence both in writing argument essays ($M = 3.57$, $SD = 0.65$) and in organizing their thoughts prior to writing ($M = 3.57$, $SD = 0.76$), pointing the steady self-assurance in both preparatory and compositional stages. The ability to construct strong arguments and counter arguments yielded a slightly lower meaning ($M = 3.43$, $SD = 0.98$), signaling greater confidence in structural awareness. Most notably, enjoyment of argumentative essay writing obtained the highest mean score ($M = 4.43$, $SD = 0.65$), suggesting that students hold a particularly favorable disposition towards this writing genre.

Taking together, the findings presented in table 2 reveal that the study participants maintain a high level of confidence and a positive perception of argumentative essay writing, which leads to support the effectiveness of the instructional approach employed throughout the study.

Table 4

Experience with Mind Mapping

Items	Indicators	Mean	SD	Level of perception
1	Mind mapping helps me plan my essay more efficiently.	4.71	0.47	Highest
2	Mind mapping allows me to organize my ideas in a logical order.	4.64	0.50	Highest
3	Using mind mapping makes brainstorming easier for me.	4.64	0.63	Highest
4	Mind mapping helps me visualize connections between my arguments.	4.50	0.52	High
5	Mind mapping encourages me to explore different perspectives in my writing.	4.21	0.43	High

Table 4 represents the respondents' perceptions on their experience with mind mapping in the context of argumentative essay writing. The mean scores range from 4.21 to 4.71, indicating overall high to highest level of perception. This suggests that students hold strongly positive views regarding the usefulness of mind mapping as a writing strategy.

The highest mean score is recorded for the item "mind mapping helps me plan my essay more efficiently" ($M = 4.71$, $SD = 0.47$), reflecting the strongest agreement among respondents. Similarly, students report that mind mapping allows them to organize their ideas logically ($M = 4.64$, $SD = 0.50$) and makes brainstorming easier ($M = 4.64$, $SD = 0.63$), both falling within the "Highest" level of perception. These findings indicate that mind mapping significantly supports the pre-writing and idea-generation stages.

Although slightly lower, the mean scores for visualizing connections between arguments ($M = 4.50$, $SD = 0.52$) and exploring different perspectives ($M = 4.21$, $SD = 0.43$) remain within the "High" level of perception. This demonstrates that students also recognize the role of mind mapping in enhancing critical thinking and conceptual clarity.

Overall, the table suggests that the use of mind mapping in the study is perceived as highly

effective, particularly in improving planning, organization and brainstorming skills in argumentative essay writing.

Table 5
Impact on Writing Skills

Items	Indicators	Mean	SD	Level of perception
1	Mind mapping has improved my ability to write clear and well-structured essays.	4.43	0.65	High
2	I am more confident in developing arguments after using mind mapping.	4.64	0.50	Highest
3	Mind mapping helps me connect ideas smoothly in my essays.	4.21	1.10	High
4	I can use a wider range of vocabulary in my essays because of mind mapping.	3.79	0.80	High
5	My critical thinking skills have improved through mind mapping.	4.07	0.62	High

Table 5 presents the respondents perceived impact of mind mapping on their writing skills across five indicators. The mean scores for all items range from 3.79 to 4.64, falling within the “High” to “Highest” levels of perception based on the adopted interpretative scale. These results collectively indicate that students recognize mind mapping as an effective instructional tool in enhancing multiple dimensions of argumentative essay writing.

Among the five indicators, the item “I am more confident in developing arguments after using mind mapping” obtained the highest mean score ($M = 4.64$, $SD = 0.50$), suggesting that the use of mind mapping substantially strengthens students’ confidence in argument development. Comparably high ratings were recorded for the items addressing the ability to write clear and well-structured essays ($M = 4.43$, $SD = 0.65$) and the capacity to connect underscore the positive influence of mind mapping on writing coherence and organizational structure.

Table 6
Student Perception and Future Use

Items	Indicators	Mean	SD	Level of perception
1	I find mind mapping to be an effective learning tool.	4.36	1.10	High
2	I feel more motivated to write essays after using mind mapping.	4.21	1.05	High
3	I believe mind mapping is useful for organizing thoughts in other subjects as well.	4.07	0.92	High
4	I would recommend mind mapping to my classmates.	4.50	1.09	High
5	I plan to continue using mind mapping for essay writing in the future.	4.36	0.93	High

Table 6 depicts the respondents’ perceptions of mind mapping and their intentions towards its future use, measured across five indicators. The mean scores for all items range from 4.07 to 4.50, consistently falling within the “High” level of perception based on the adopted interpretative scale. These results suggest that students hold a favorable view of mind mapping as an effective and meaningful learning strategy.

With respect to specific indicators, students express strong agreement that mind mapping is effective for learning ($M = 4.36$, $SD = 1.08$) and that it increases their motivation to engage in essay writing ($M = 4.21$, $SD = 1.05$). These findings reflect the positive influence of mind mapping on students’ learning attitudes and overall engagement in the writing process. Moreover, the perception that mind mapping can be applied to organize thoughts across other subject areas ($M = 4.07$, $SD = 0.92$) underscores its recognized versatility as a cognitive organizational tool that

transcends the boundaries of essay writing alone.

3.3. Findings Based on Qualitative Data

The semi-structured interview was conducted with eight purposively selected students to gain an in-depth understanding of their experiences with mind mapping as an instructional strategy in argumentative essay writing. The survey consisted of seven guiding questions that explored students' prior writing challenges, their experiences using mind mapping, its perceived impact on essay structure and argumentation, difficulties encountered, and overall confidence development. The responses were analyzed thematically to identify recurring patterns and meaningful observations across the participants.

3.3.1. Theme 1: Writing challenges prior to the use of mind mapping

Prior to the integration of mind mapping, participants reported experiencing considerable difficulties in their ideas and constructing coherent argumentative essays. Common challenges included developing clear and focused thesis statements, structuring introductions effectively, and maintaining logical flow and coherence throughout their writing.

For instance, one student (P2) noted:

I felt it difficult to write the background and the thesis statement because I was not sure how to begin the introduction and connect my ideas properly. Sometimes I had ideas, but I could not organize them in a clear way.

A similar sentiment was echoed by another participant (P5), who stated:

My writing lacked organization and I often did not know how to arrange my points. I would write ideas randomly, and sometimes my essay did not make sense when I read it again.

Further elaborating on these difficulties, P7 remarked:

There was overlap of ideas, limited vocabulary, and repetition of points. I found it difficult to connect my arguments, and I was not confident about how to structure my essay properly.

Collectively, these responses suggest that students lacked effective pre-writing strategies, which resulted in fragmented and poorly organized essays. Before the introduction of mind mapping. From an analytical standpoint, this reflects a deficit in cognitive scaffolding — students were insufficiently supported in the processes of organizing, sequencing, and structuring their ideas prior to engaging in the act of writing.

3.3.2. Theme 2: Experience using mind mapping for essay planning

Upon using mind mapping as a planning tool, respondents generally reported positive experiences that facilitated a more structured and efficient writing process. A predominant observation among participants was that mind mapping reduced the time required to outline and plan their essays, making the planning stage more manageable. For example, student P3 noted:

It helped in planning the essay. And I could see my ideas before writing. I found that it takes less time to frame the plan, and I did not feel confused about how to begin or organize my points. I found that it takes less time to frame the plan of the essay.

Another student (P6) explained:

The visual representation helped me stay focused on my topic and organize my ideas properly. I could connect my points more clearly, and it made the whole writing process easier and more structured than before.

These responses indicate that mind mapping was well-received as a pre-writing strategy that supported cognitive organization and planning, enabling students to approach writing more systematically.

3.3.3. Theme 3: Impact on idea generation and organizational coherence

With respect to idea generation and organizational coherence, many respondents acknowledged that mind mapping played a meaningful role in enhancing these aspects of their writing. Students reported that mind mapping helped them generate relevant ideas more effectively and maintain

focus throughout the writing process.

For instance, one participant (P4) explained:

Mind mapping helped me generate more ideas because I could see my points clearly in one place. It allowed me to think more deeply about my topic and organize my points in a logical way before I started writing.

Another student (P1) noted:

It helped me structure my essay better because I could not connect my ideas and arrange them step by step. This made my writing more organized and helped me stay focused on the main points throughout the essay.

However, one respondent (P8) offered a different perspective:

It only helped me to organize my essay in chronological way, but it did not really help me generate new ideas, especially when I did not have much knowledge about the topic. I still found it difficult to think of new points and develop my arguments further.

Despite this isolated response, the overall findings suggest that mind mapping supported both idea generation and organizational coherence, enabling students to develop more structured and focused argumentative essays.

3.3.4. Theme 4: Impact on essay structure and logical flow

The respondents consistently reported that mind mapping contributed to improvements in the structure and logical flow of their argumentative essays. Students indicated that their essays became more organized, coherent, and logically sequenced following the use of mind mapping. For instance, one student stated, "It helped me to generate ideas for arguing and refuting." Another participant mentioned that "it helped me build strong arguments because I did not miss my points." The recurring emphasis on improved structure and logical coherence across multiple responses reinforces the value of mind mapping as a tool for developing well-organized argumentative compositions.

3.3.5. Theme 5: Development of arguments and counterarguments

Regarding the development of arguments and counterarguments, responses were generally favorable, through some participants acknowledged initial difficulties. Several students reported that mind mapping facilitated the generation and organization of arguments, with one respondent noting that it helped in building strong arguments without overlooking key points. For instance, P7 stated:

When I used mind mapping, I could lay out my ideas visually, which made it easier to see connections between my points. It helped me to generate ideas for arguing and refuting, and I could make sure I didn't leave out anything important.

Similarly, P1 highlighted the effect on the clarity and strength of their arguments, stating:

It helped me build strong arguments because I did not miss my points. Seeing mapped out made me more confident in presenting my ideas logically and I could easily identify where I needed more evidence or explanation.

However, a few respondents indicated that generating counterarguments was challenging at the outset. P3 reflected:

At first, I found it really hard to think of the opposing views. I would get stuck and not know what to say. But as I kept practicing with mind maps, it became easier to see what the other side might argue, and I started to plan my rebuttals more effectively.

These findings suggest that while mind mapping supports the argumentation process by strengthening idea generation and organization, its full benefits in developing counterarguments may require sustained and repeated application.

3.3.6. Theme 6: Challenges encountered and coping strategies

Despite the overall positive reception of mind mapping, respondents identified several challenges encountered during its implementation. Technical difficulties, including limited internet

connectivity and power interruptions, were cited by some participants as obstacles to completing online mind mapping activities. P5 explained:

At first, it was difficult because the internet kept cutting off, and I lost some of my work. It was frustrating in the beginning, but as I became more familiar with the platform and found ways to save my progress, it improved with time.

Others reported challenges related to time management, noting that the process required additional time that encroached upon personal leisure. P3 reflected:

I had to spend my extra hours organizing my ideas, which meant less time for other activities. It felt a bit overwhelming at first, but I realized that this extra effort helped me understand my arguments better.

Difficulties in rephrasing ideas and articulating the thesis were also mentioned. P2 stated:

I sometimes struggled to put my ideas into the right words or connect them logically. Mind mapping helped me visualize the flow, but it still took practice to express everything clearly.

In terms of coping strategies, students reported seeking assistance from teachers and utilizing available digital resources to address conceptual difficulties. P2 noted, "Whenever I got stuck, I asked my teacher for guidance or watched tutorial videos online. Slowly, I learned how to organize my ideas more effectively." Others indicated that consistent practice led to gradual improvement. These responses highlight the importance of providing adequate logistical support and scaffolding when implementing mind mapping in instructional settings, ensuring that students can overcome technical and conceptual challenges while maximizing the benefits of this tool.

3.3.7. Theme 7: Overall confidence in argumentative essay writing

The final survey question addressed whether mind mapping improved students' overall confidence in writing argumentative essays. The responses were overwhelmingly affirmative, with many participants expressing that mind mapping enhanced their confidence and competence as writers. Students reported improvements in writing clarity, structural organization, critical thinking, and the ability to present ideas in a coherent and well-developed format. For instance, P6 explained:

It helped me to generate ideas for arguing and refuting. Seeing my ideas laid out visually made it easier to organize my thoughts and ensure that I was covering all important points.

Another respondent, P3, reflected on the creative benefits of mind mapping:

The visual nature of the mind map made it easier to think creatively and explore different perspectives. I could see connections between ideas that I might have missed if I were just writing in a linear way.

P5 emphasized the impact on academic performance: "Using mind maps has made me more organized and confident in my essays. My grades improved, and I feel more capable of tackling complex arguments."

These qualitative responses align closely with the quantitative findings reported in the preceding tables and collectively affirm that mind mapping serves as an effective confidence-building strategy in the context of argumentative essay instruction.

3.4. Research Diary

The research diary shows a strong alignment between the qualitative results and the qualitative findings from the semi-structured interviews. Initial classroom observations and the pretest score revealed that students struggled with organizing ideas, developing thesis statements, and maintaining coherence in argumentative essays. Many students also demonstrated low confidence in structuring argumentative essays.

Many students also demonstrated low confidence in structuring arguments and counterarguments effectively. Following the implementation of the four-week intervention using digital mind mapping (MindMeister), students exhibited improved planning strategies, clearer

organization of ideas, stronger logical flow, and greater engagement in the writing process. These qualitative improvements were supported by a noticeable increase in posttest scores and a substantial effect size (Cohen's *d*), indicating a meaningful impact of the intervention.

Overall, both the statistical evidence and students' reflections confirm that digital mind mapping significantly enhanced the organization, coherence, and confidence of grade 12 students in argumentative essay writing.

4. Discussion

The findings of this study extend beyond demonstrating improvement in students' writing performance and instead highlight the role of digital mind mapping as a form of technology-supported pedagogical innovation in secondary education. The significant improvement between pretest and posttest scores indicates that integrating digital tools into the writing process can meaningfully enhance students' ability to organize and articulate arguments (Buzan & Buzan, 2010). More importantly, the study reveals how such tools function as digitally mediated scaffolds that support structured, student-centered learning (Sweller, 1988; Flower & Hayes, 1981).

From a digital pedagogy perspective, the use of MindMeister represents a shift from traditional, teacher-directed writing instruction toward a more learner-centered and interactive approach. Rather than passively receiving information about essay structure, students actively engaged in constructing and organizing their ideas through a visual and flexible digital environment (Warschauer, 2004). This aligns with contemporary views of digital pedagogy, where technology is not merely used for delivery but serves as a medium through which learners actively create, manipulate, and refine knowledge (Buzan & Buzan, 2010; Flower & Hayes, 1981).

The findings also demonstrate that digital mind mapping serves as an effective form of cognitive and organizational scaffolding. By breaking down the complex task of argumentative writing into manageable visual components—such as thesis, supporting arguments, counter arguments, and evidence—the tool enabled students to better understand and control the structure of their essays (Toulmin, 2003). This scaffolded approach reduced cognitive overload (Sweller, 1988) and allowed learners to focus more effectively on developing coherent and logically sequenced arguments. Importantly, the scaffold was not imposed externally but was interactively constructed by students, reinforcing autonomy and deeper engagement in the writing process.

In terms of technology-supported writing instruction, the study provides evidence that digital planning tools can significantly enhance both the process and outcomes of writing. The visual and dynamic nature of digital mind maps enabled students to revisit, reorganize and expand their ideas with ease, supporting interactive thinking and continuous refinement (Buzan & Buzan, 2010). This process-oriented approach aligns with contemporary models of writing instruction that emphasize planning, drafting, and revising as recursive and interconnected stage (Flower & Hayes, 1981). As a result, writing becomes not a linear task but a dynamic and evolving cognitive activity supported by technology.

Another key contribution of this study lies in its implications for sustainable writing support practices. Unlike one-time instructional strategies, digital mind mapping offers a reusable and transferable framework that students can apply across different writing tasks and subject areas. The ability to independently generate and organize ideas using a digital tool suggests that students are developing skills that extend beyond the immediate classroom context, supporting long-term academic development and independent learning habits (Sweller, 1988; Buzan & Buzan, 2010).

Furthermore, the findings indicate strong potential for scalable digital classroom innovation. Given the accessibility of digital mind mapping tools and the increasing availability of technological infrastructure in schools, such practices can be adapted and implemented across diverse educational contexts. The positive student perceptions, increased engagement, and measurable improvements in writing performance suggest that this approach is not limited to a small group but has broader applicability in secondary education (Warschauer, 2004; Toulmin, 2003). With appropriate support and training, digital mind mapping can be integrated into regular classroom practice as a scalable model for enhancing writing instruction.

Despite these contributions, the study acknowledges certain limitations, including the small sample size and the absence of a control group, which may affect the generalizability of the findings. Additionally, technical challenges such as internet connectivity highlight the importance of reliable infrastructure in implementing digital pedagogy effectively (Warschauer, 2004). These factors suggest that while digital tools offer significant pedagogical benefits, their success depends on contextual and institutional support systems.

Overall, this study demonstrates that digital mind mapping should be understood not merely as a classroom technique but as a digitally mediated pedagogical scaffold that supports structured, learner-centered, and sustainable writing development. By integrating technology into the cognitive processes of planning and organization, it contributes to a broader understanding of how digital pedagogy can transform writing instruction in secondary classrooms (Buzan & Buzan, 2010; Flower & Hayes, 1981; Toulmin, 2003; Sweller, 1988; Warschauer, 2004).

5. Reflection

The action research conducted in the Grade 12 class revealed meaningful progress in improving student's organization and coherence in argumentative essay writing through digital mind mapping. One of the positive outcomes was the significant improvement in pretest scores, supported by a substantial effect size, indicating that the intervention had a strong impact on students' writing performance. The structured use of Mind Meister enabled students to plan more effectively, develop clearer thesis statements, and construct logically connected arguments and counterarguments.

Classroom observations recorded in the research diary also highlighted noticeable changes in students' engagement and confidence. Students became more focused during the planning stage, participated more actively in discussions, and demonstrated greater independence in organizing their ideas before drafting. Many relied on the visual framework of the mind map to stay on track and reduce repetition. Interview responses further confirmed that students felt more confident, creative, and critically aware of how to structure their essays.

Moving forward, the next step is to refine the strategy by combining digital mind mapping with explicit instruction on argument development and peer review practices. Future action research cycles could involve a larger group of students, integrate collaborative mind mapping activities, and extend the intervention period to examine long-term improvements in writing proficiency. Continuous reflection period through the research diary will support ongoing adjustments and ensure sustained enhancement of argumentative writing skills.

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