



Structured Brainstorming Strategies in Improving Critical Thinking Skills and Environmental Attitude of Grade 10 Students

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Abstract— This study examines the effects of structured brainstorming strategies — specifically mind mapping and brainwriting — on the critical thinking skills and environmental attitude of Grade 10 students at Gloria Umali Integrated National High School. Using an experimental research design and cluster random sampling, data were collected from 62 students who completed researcher-developed tests and questionnaires. Frequency, weighted mean, and standard deviation were used to analyze pretest and posttest performance, and a paired-sample t-test was employed to assess significant differences. Findings revealed marked improvement in students' critical thinking skills after exposure to both strategies. Brainwriting also significantly enhanced students' environmental attitude, whereas mind mapping did not produce statistically significant changes in this domain. Recommendations include developing interdisciplinary teaching approaches that integrate environmental issues and further exploring brainstorming strategies for students' holistic development.

Keywords— Structured Brainstorming, Mind Mapping, Brainwriting, Critical Thinking Skills, Environmental Attitude.

I. INTRODUCTION

The use of brainstorming strategies across disciplines has been widely recognized for achieving educational goals. This technique was first introduced by Dr. Alex Osborn in 1953; it is an organized, rule-governed method for soliciting ideas, in which immediate evaluation of ideas is not allowed (Kirk & Spreckelmeyer, 2021). Osborn (2022) proposed four guiding principles: (1) no judgment, (2) freewheeling, (3) quantity production, and (4) search to improve ideas.

Brainstorming is an established method for creative problem-solving (Fernald & Nickolenko, 2024). The growing need for high-quality ideas generated through brainstorming is particularly relevant to the social sciences (Ganji, 2022). Furthermore, brainstorming and its connection to cognitive development are closely linked to critical thinking — a concept defined by Dewey as 'an active, persistent, and careful consideration of a belief or supposed form of knowledge' (as cited in Fisher, 2021).

On the other hand, environmental education is a powerful tool for influencing student behavior toward sustainability. Lopez et al. (2021) show that brainstorming sessions strengthen students' motivation and involvement in environmental fields. Kim and Park (2020) also agreed that brainstorming promotes collaborative learning, which has a direct bearing on pro-environmental behavior formation.



II. METHODOLOGY

A. Research Design

The research methodology employed was a two-group pretest-posttest experimental design aimed at evaluating the influence of structured brainstorming techniques on the development of critical thinking skills and environmental attitude of Grade 10 students.

B. Respondents of the Study

The participants were sixty-two Grade 10 students from the Charity and Unity sections of Gloria Umali Integrated National High School (GUINHS) for School Year 2025–2026. They were selected through cluster random sampling.

C. Research Instruments

A researcher-developed essay-type test with a corresponding scoring rubric was used to assess critical thinking skills, while a researcher-developed questionnaire evaluated environmental attitudes.

D. Statistical Treatment of Data

Descriptive and inferential statistics were employed. A frequency distribution analyzed critical thinking levels; the weighted mean and standard deviation described environmental attitude scores. A paired-sample t-test determined significant differences between pretest and posttest results.

III. RESULTS AND DISCUSSION

A. Performance of Students Exposed to Mind Mapping Technique

Table 1. Pretest and Posttest of Critical Thinking Skills in Intellectual Standards (Mind Mapping)

INTELLECTUAL STANDARDS	Pretest		Posttest		Verbal Interpretation
	N	%	N	%	
1.00–1.80	2	6.5%			Beginning
1.81–2.60	15	48.4%			Developing
2.61–3.20	9	29.0%	6	19.4%	Good
3.21–4.00	5	16.1%	25	80.6%	Excellent
Total	31	100%	31	100%	

Legend: 1.0–1.80 = Beginning; 1.81–2.60 = Developing; 2.61–3.20 = Good; 3.21–4.00 = Excellent

Students' critical thinking skills, assessed against intellectual standards, improved significantly after exposure to mind mapping. Most students initially classified as 'Developing' achieved 'Excellent' on the posttest, indicating that mind mapping helped learners organize ideas more clearly and logically.

These findings support Arulsevi (2022) and Morales and Santiago (2021), who highlighted that guided brainstorming activities improve students' analytical and evaluative thinking abilities.

Table 2. Pretest and Posttest of Critical Thinking Skills in Elements of Thoughts (Mind Mapping)

ELEMENTS OF THOUGHTS	Pretest		Posttest		Verbal Interpretation
	N	%	N	%	
1.00–1.80	2	6.5%			Beginning
1.81–2.60	16	51.6%			Developing
2.61–3.20	7	22.6%	5	16.1%	Good
3.21–4.00	6	19.4%	26	83.9%	Excellent
Total	31	100%	31	100%	

Legend: 1.0–1.80 = Beginning; 1.81–2.60 = Developing; 2.61–3.20 = Good; 3.21–4.00 = Excellent

Learners who previously struggled to organize assumptions and inferences became more adept at presenting logical, coherent answers. Visual organization through mind maps simplified complex ideas and strengthened reasoning skills, consistent with findings from Shi et al. (2022) and Al-Jarf (2021).

Table 3. Pretest and Posttest of Critical Thinking Skills in Intellectual Traits (Mind Mapping)

INTELLECTUAL TRAITS	Pretest		Posttest		Verbal Interpretation
	N	%	N	%	
1.00–1.80	4	12.9%			Beginning
1.81–2.60	22	71.0%	3	9.7%	Developing
2.61–3.20	5	16.1%	20	64.5%	Good
3.21–4.00			8	25.8%	Excellent
Total	31	100%	31	100%	

Legend: 1.0–1.80 = Beginning; 1.81–2.60 = Developing; 2.61–3.20 = Good; 3.21–4.00 = Excellent

Mind mapping improved students' intellectual empathy and integrity. Collaborative brainstorming helped learners appreciate diverse perspectives, thereby strengthening their intellectual integrity — a finding echoed by Santos (2022).

Table 4. Level of Egoistic Environmental Attitude Exposed to Mind Mapping

Statements	Pretest			Posttest		
	Mean	SD	Interp.	Mean	SD	Interp.
EA 1	3.23	.425	High	3.32	.475	High
EA 2	3.35	.486	High	3.29	.461	High
EA 3	3.26	.514	High	3.26	.514	High
EA 4	3.00	.632	High	3.06	.629	High
EA 5	3.52	.508	Very High	3.55	.506	Very High
EA 6	3.06	.442	High	3.13	.499	High
EA 7	3.39	.495	High	3.42	.564	High
EA 8	3.19	.402	High	3.29	.461	High



EA 9	3.23	.560	High	3.26	.631	High
Overall	3.2473	.16902	High	3.2867	.21038	High

Legend: 3.50–4.0 (Very High); 2.50–3.49 (High); 1.50–2.49 (Low); 1.0–1.49 (Very Low)

Students consistently demonstrated a 'High' egoistic environmental attitude before and after the intervention. Bouman et al. (2018) noted that egoistic individuals are less inclined to engage in pro-environmental behavior unless they perceive direct personal gains — suggesting the need to help students recognize the long-term personal benefits of conservation.

Table 5. Level of Altruistic Environmental Attitude Exposed to Mind Mapping

Statements	Pretest			Posttest		
	Mean	SD	Interp.	Mean	SD	Interp.
AL 1	3.06	.442	High	3.10	.473	High
AL 2	3.48	.570	High	3.45	.624	High
AL 3	2.94	.574	High	2.94	.629	High
AL 4	3.10	.700	High	3.16	.735	High
AL 5	3.19	.402	High	3.19	.477	High
AL 6	3.00	.632	High	3.06	.680	High
AL 7	3.00	.632	High	3.06	.680	High
AL 8	3.06	.574	High	3.13	.619	High
AL 9	3.35	.486	High	3.42	.502	High
Overall	3.1326	.34596	High	3.1685	.38262	High

Legend: 3.50–4.0 (Very High); 2.50–3.49 (High); 1.50–2.49 (Low); 1.0–1.49 (Very Low)

The findings showed a 'High' altruistic environmental attitude, indicating awareness of moral and social responsibility toward the environment. However, students' willingness to reduce their carbon footprint remained relatively low, suggesting that awareness did not always translate into action.

Table 6. Level of Biospheric Environmental Attitude Exposed to Mind Mapping

Statements	Pretest			Posttest		
	Mean	SD	Interp.	Mean	SD	Interp.
BI 1	3.42	.502	High	3.52	.508	Very High
BI 2	3.29	.588	High	3.29	.588	High
BI 3	3.55	.506	Very High	3.58	.502	Very High
BI 4	2.97	.547	High	3.03	.605	High
BI 5	3.35	.486	High	3.32	.475	High
BI 6	3.48	.570	High	3.42	.564	High
BI 7	3.23	.560	High	3.19	.543	High
BI 8	3.29	.588	High	3.29	.588	High



BI 9	3.29	.588	High	3.29	.588	High
Overall	3.3172	.19834	High	3.3262	.34179	High

Legend: 3.50–4.0 (Very High); 2.50–3.49 (High); 1.50–2.49 (Low); 1.0–1.49 (Very Low)

Students exhibited a 'High' biospheric environmental attitude even before the intervention. Mind mapping produced only minimal improvement, particularly in behavioral commitment.

As Garcia and Lee (2024) argued, experiential and action-based activities may be more effective at strengthening environmental attitudes than cognitive strategies alone.

B. Performance of Students Exposed to Brainwriting Technique

Table 7. Pretest and Posttest of Critical Thinking Skills in Intellectual Standards (Brainwriting)

INTELLECTUAL STANDARDS	Pretest		Posttest		Verbal Interpretation
	N	%	N	%	
1.81–2.60	23	74.2%	2	6.5%	Developing
2.61–3.20	8	25.8%	19	61.3%	Good
3.21–4.00			10	32.3%	Excellent
Total	31	100%	31	100%	

Legend: 1.0–1.80 = Beginning; 1.81–2.60 = Developing; 2.61–3.20 = Good; 3.21–4.00 = Excellent

Brainwriting techniques significantly improved students' intellectual standards. Learners became more accurate, precise, and analytical — a result consistent with Johnson et al. (2019) and Kirk and Spreckelmeyer (2021), who emphasized that structured brainstorming enhances critical thinking through idea exchange and reflection.

Table 8. Pretest and Posttest of Critical Thinking Skills in Elements of Thoughts (Brainwriting)

ELEMENTS OF THOUGHTS	Pretest		Posttest		Verbal Interpretation
	N	%	N	%	
1.00–1.80	9	29.0%			Beginning
1.81–2.60	18	58.1%			Developing
2.61–3.20	4	12.9%	3	9.7%	Good
3.21–4.00			28	90.3%	Excellent
Total	31	100%	31	100%	

Legend: 1.0–1.80 = Beginning; 1.81–2.60 = Developing; 2.61–3.20 = Good; 3.21–4.00 = Excellent

Most students progressed from 'Developing' to 'Excellent' after the brainwriting intervention.

The strategy enabled learners to logically organize ideas, identify assumptions, and support inferences with evidence — highlighting the effectiveness of collaborative writing in improving cognitive processing.

Table 9. Pretest and Posttest of Critical Thinking Skills in Intellectual Traits (Brainwriting)

INTELLECTUAL TRAITS	Pretest		Posttest		Verbal Interpretation
	N	%	N	%	
1.00–1.80	3	9.7%			Beginning
1.81–2.60	25	80.6%	1	3.2%	Developing
2.61–3.20	3	9.7%	9	29.0%	Good
3.21–4.00			21	67.7%	Excellent
Total	31	100%	31	100%	

Legend: 1.0–1.80 = Beginning; 1.81–2.60 = Developing; 2.61–3.20 = Good; 3.21–4.00 = Excellent

Students' intellectual traits improved markedly as they exchanged ideas, with learners developing intellectual empathy, open-mindedness, and integrity. These findings align with Ennis (2011), who emphasized that nurturing intellectual curiosity and open-mindedness strengthens critical thinking and lifelong learning skills.

Table 10. Level of Egoistic Environmental Attitude Exposed to Brainwriting

Statements	Pretest			Posttest		
	Mean	SD	Interp.	Mean	SD	Interp.
EA 1	3.55	.506	Very High	3.32	.541	High
EA 2	3.19	.402	High	3.48	.570	High
EA 3	3.26	.514	High	3.42	.502	High
EA 4	3.26	.445	High	3.06	.629	High
EA 5	3.55	.506	Very High	3.87	.428	Very High
EA 6	3.48	.626	High	3.13	.562	High
EA 7	3.77	.425	Very High	3.58	.502	Very High
EA 8	3.35	.486	High	3.39	.558	High
EA 9	2.87	.499	High	3.32	.599	High
Overall	3.3656	.20726	High	3.3978	.25624	High

Legend: 3.50–4.0 (Very High); 2.50–3.49 (High); 1.50–2.49 (Low); 1.0–1.49 (Very Low)

Students maintained a 'High' egoistic environmental attitude, with a slight improvement after brainwriting. This is supported by Mahmoudi and Ozkan (2022), who observed that brainstorming sessions increase emotional concern for sustainable practices, and by Lou et al. (2024), who noted that egoistic values may encourage pro-environmental behavior when environmental issues become personally relevant.

Table 11. Level of Altruistic Environmental Attitude Exposed to Brainwriting

Statements	Pretest			Posttest		
	Mean	SD	Interp.	Mean	SD	Interp.
AL 1	3.10	.473	High	3.26	.445	High
AL 2	3.13	.499	High	3.55	.506	Very High
AL 3	2.61	.558	High	3.13	.428	High



AL 4	2.77	.669	High	3.39	.667	High
AL 5	3.10	.301	High	3.42	.502	High
AL 6	3.00	.365	High	3.06	.629	High
AL 7	2.94	.442	High	3.32	.541	High
AL 8	3.32	.475	High	3.19	.477	High
AL 9	3.87	.341	Very High	3.74	.445	Very High
Overall	3.0932	.27681	High	3.3405	.27358	High

Legend: 3.50–4.0 (Very High); 2.50–3.49 (High); 1.50–2.49 (Low); 1.0–1.49 (Very Low)

Brainwriting increased students' altruistic environmental attitudes by fostering awareness of others' concerns and collective social responsibility. Students demonstrated greater empathy for environmental issues — findings similar to those of Mulyani et al. (2021), who found that brainstorming enhances environmental consciousness through collaborative reflection.

Table 12. Level of Biospheric Environmental Attitude Exposed to Brainwriting

Statements	Pretest			Posttest		
	Mean	SD	Interp.	Mean	SD	Interp.
BI 1	3.81	.402	Very High	3.58	.502	Very High
BI 2	3.23	.560	High	3.48	.570	High
BI 3	3.55	.506	Very High	3.65	.486	Very High
BI 4	2.58	.620	High	3.35	.551	High
BI 5	3.23	.425	High	3.45	.506	High
BI 6	3.10	.301	High	3.52	.508	Very High
BI 7	3.03	.407	High	3.52	.508	Very High
BI 8	3.16	.523	High	3.58	.502	Very High
BI 9	3.06	.250	High	3.61	.558	Very High
Overall	3.1935	.25974	High	3.5269	.25494	Very High

Legend: 3.50–4.0 (Very High); 2.50–3.49 (High); 1.50–2.49 (Low); 1.0–1.49 (Very Low)

Students' biospheric environmental attitude shifted from 'High' to 'Very High' after brainwriting, reflecting stronger emotional bonds to nature and greater willingness to participate in environmental protection activities — consistent with Smith and Williams (2023) and Garcia and Lee (2024).

C. Test of Significant Paired Difference Between Variables

Table 13. Significant Difference in Critical Thinking Skills Exposed to Mind Mapping

	Mean	Std. Dev.	Std. Error Mean	95% CI Lower	95% CI Upper	t	Sig. (2-tailed)
Intellectual Standards	0.9548	0.4668	0.0838	0.7836	1.1261	11.389	0.000
Elements of Thoughts	0.8839	0.5699	0.1023	0.6748	1.0929	8.636	0.000



Intellectual Traits	0.7935	0.4575	0.0822	0.6257	0.9614	9.658	0.000
Overall CTS	0.87742	0.33115	0.05948	0.75595	0.99889	14.753	0.000

Critical value of *t*-test (two-tailed): $P < .01 \pm 2.750$, $P = 0.001$, ± 3.646

Students' critical thinking skills improved significantly after mind mapping. The greatest gains were observed in intellectual standards and elements of thought, confirming that mind mapping is effective in enhancing logical analysis and information organization. Paulus and Nijstad (2019) noted that structured brainstorming not only generates ideas but also refines them to increase innovation.

Table 14. Significant Difference in Environmental Attitude Exposed to Mind Mapping

	Mean	Std. Dev.	Std. Error Mean	95% CI Lower	95% CI Upper	t	Sig. (2-tailed)
Egoistic	0.03943	0.14501	0.02604	-0.01376	0.09262	1.514	0.141
Altruistic	0.03584	0.18897	0.03394	-0.03347	0.10516	1.056	0.299
Biospheric	0.00896	0.29818	0.05355	-0.10041	0.11833	0.167	0.868
Overall Environmental Attitude	0.02808	0.17112	0.03073	-0.03469	0.09085	0.914	0.368

Critical value of *t*-test (two-tailed): $P < .01 \pm 2.750$, $P = 0.001$, ± 3.646

Mind mapping did not produce a significant change in environmental attitudes. The statistically insignificant differences may be attributable to deeply rooted emotional factors, as Otto and Pensini (2017) found that emotional attachment to nature is a primary determinant of environmental attitudes. Rosa and Collado (2019) further show that pro-environmental behavior develops through experiential learning.

Table 15. Significant Difference in Critical Thinking Skills Exposed to Brainwriting

	Mean	Std. Dev.	Std. Error Mean	95% CI Lower	95% CI Upper	t	Sig. (2-tailed)
Intellectual Standards	.7935	.5452	.0979	.5936	.9935	8.103	.000
Elements of Thoughts	1.3935	.5876	.1055	1.1780	1.6091	13.204	.000
Intellectual Traits	1.2323	.5218	.0937	1.0409	1.4236	13.149	.000
Overall CTS	1.13978	.33482	.06014	1.01697	1.26260	18.954	.000

Critical value of *t*-test (two-tailed): $P < .01 \pm 2.750$, $P = 0.001$, ± 3.646

Brainwriting led to significant improvements across all three dimensions of critical thinking. Students demonstrated enhanced clarity, logical reasoning, and reflective thinking. This aligns with Paulus and Kenworthy (2019) and Al-Samarraie and Hurmuzan (2018), who emphasized that collaborative writing activities strengthen structured thinking and reasoning.



Table 16. Significant Difference in Environmental Attitude Exposed to Brainwriting

	Mean	Std. Dev.	Std. Error Mean	95% CI Lower	95% CI Upper	t	Sig. (2-tailed)
Egoistic	.03226	.29564	.05310	-.07618	.14070	.608	.548
Altruistic	.24731	.32294	.05800	.12886	.36577	4.264	.000
Biospheric	.33333	.35947	.06456	.20148	.46519	5.163	.000
Overall Environmental Attitude	.20430	.26099	.04688	.10857	.30003	4.358	.000

Critical value of t-test (two-tailed): $P < .01 \pm 2.750$, $P = 0.001$, ± 3.646

Brainwriting significantly enhanced students' altruistic and biospheric environmental attitudes, whereas egoistic values changed only marginally. Shared brainstorming and exposure to diverse perspectives fostered pro-social and pro-environmental values — consistent with Van der Werff and Steg (2016) and Imaningsih et al. (2023), who identified altruistic and biospheric values as the most powerful determinants of pro-environmental beliefs.

IV. CONCLUSIONS

The null hypothesis of no significant difference in critical thinking skills before and after mind mapping exposure is rejected. However, the null hypothesis of no significant difference in environmental attitude following mind mapping exposure is accepted.

The null hypothesis of no significant difference in critical thinking skills and environmental attitude before and after brainwriting exposure is rejected.

Brainwriting significantly improved both dimensions. Overall, both strategies effectively enhanced critical thinking, but their effects on environmental attitude diverged — brainwriting proved superior in this domain.

V. RECOMMENDATIONS

Teachers may adopt brainstorming strategies — particularly brainwriting — to encourage student engagement, develop analytical thinking, and promote environmental awareness. School administrators can use these findings to design professional development programs and workshops focused on cognitively engaging teaching strategies.

Future researchers may explore the impact of structured brainstorming on other dimensions of student development, such as creativity, problem-solving, and social responsibility, as well as its effectiveness across different subject areas and grade levels.

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