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RESEARCH ARTICLE

Catalyzing Creativity and Critical Thinking Through Science Graphic Organizers

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ABSTRACT

This research aimed to examine the perceived effectiveness of graphic organizers in catalyzing creativity and critical thinking skills among 6th-grade pupils of the College of Teacher Education- Laboratory School, Batangas State University ARASOF Nasugbu, A.Y. 2020-2021. The explanatory sequential mixed method research design was utilized in this study. The results revealed that graphic organizers were useful tools to enhance understanding of concepts, retention, and content mastery as respondents' post-test results improved comparatively higher than their pre-test. Additionally, the informants' statements strengthened the results that graphic organizers can catalyze learners' creative and critical thinking.

INTRODUCTION

In this era of knowledge-based society, school curricula must center on developing learners' creativity and critical thinking skills. In the Philippines, the K to 12 science curricula develop learners to be scientific thinkers, technology-oriented, and environment-sensitive citizens as they are provided with a repertoire of competencies. As a result, they become productive members of society. They are characterized by being critical in problem-solving, taking responsibility as stewards of nature, being creative and innovative individuals, creating informed decisions, and communicating effectively [1].

Based on the idea presented, it can be expected that learners develop creative and critical thinking that contributes to their scientific literacy. However, the data from standardized examinations negate this conception [2-4]. Recently, Filipino learners recorded an average of 357 points in science literacy [4], which was comparatively lower than the Organization for Economic Co-operation and Development (OECD) average of 489 points. The continuous decline in Science academic performance among learners manifests in the mean percentage scores in Science, 66.11, 30.94, and 29.05 on The National Achievement Tests [2,3]. Examinations were administered last S. Y. 2011-2012, 2016-2017, and 2017-2018, respectively. With these pieces of evidence, there is an urgency to improve and recalibrate science instruction.

Research exploring the correlation between critical, creative thinking abilities, and learning achievement revealed that learning is affected by creative and critical thinking abilities; these abilities' empowerment can improve education. It was concluded that there was a significant correlation between creative thinking abilities, necessary thinking abilities, and learners' cognitive learning outcomes. Further, it was claimed that innovative learning and critical and creative thinking abilities might be improved [5].

Critical thinking is at the heart of any academic practice that requires learners' understanding or creating an argument, using pieces of evidence to validate that argument, drawing rational assumptions, and using facts to resolve challenges and conflicts [6].

In this connection, creative thinking includes learning to build and implement fresh solutions in diverse situations, viewing existing problems in a new light, seeking plausible theories, and seeing or innovating different links that generate meaningful outcomes.

To investigate options, construct theories and concepts, and function on intuition, this includes combining pieces into unique, wading, and transforming thoughts [7].

As a response, several researchers have found graphic organizers' instructional potentials in improving academic performance among learners. They utilized graphic organizers to improve writing descriptive texts, promote reading comprehension, basic Science, and mathematics.

Graphic organizers are illustrative images that consist of lines, arrows, and circles that coordinate the visual type of ideas and concepts to allow interaction between thoughts, enhance or alter their knowledge of the context by looking into the ties and inconsistencies between general information and novel concepts [8,9].

As a graphical medium of communication that uses mental images to express thoughts and ideas and transmit context, graphic organizers stimulate students to use creative ways to think about knowledge and improve their critical thinking skills by promoting learning [10]. In other words, graphic organizers are helpful in the teaching of students inside and outside classrooms. Additionally, these are useful tools for successful learning that can help educators and learners enhance knowledge, encourage critical thinking, and achieve high expectations in increasingly diverse classrooms.

A study delved into concept mapping's effect on learners' achievement in Science subjects. A quasi-experimental study showed that learners' academic gains in science statistically improved than the traditional way of delivering instruction [11]. A similar study highlighted that the participants in the experimental group achieved significantly better when compared to the control group participants. Additionally, the participants have a deeper understanding of concepts, retention, and mastery of contents as they confidently and actively indulge in graphic organizer guided activities [12].

Similarly, a study found out that graphic organizers in the class contributed to easy retention of concepts and topics of learners [13]. Quasi-experimental research focused on the effects of graphic organizers among learners' ability in writing descriptive texts. The study revealed that graphic organizers significantly impact learners' ability to write descriptive text [14,15].

On the other hand, some research findings negate the claims mentioned above on graphic organizers' effectiveness in increasing academic achievement and improving learners' ability to explain information. A study iterated that graphic organizers only help alleviate the learners' example pattern mentality but do not likely enhance conceptual understanding. Further, it was asserted that there was no guarantee to increase academic achievement when graphic organizers were utilized [16]. Additionally, a research study articulated that explicit organizer-based teaching material has been ineffective in improving learners' ability to explain information [9].

Previous researches explored much on graphic organizers effectiveness in improving academic performance in Science and other various subjects. Researchers have utilized a quasi-experimental design to describe the instructional significance of graphic organizers quantitatively. However, whether graphic organizers can catalyze creative and critical thinking abilities remains less explored.

Thus, this study aimed to fill in the existing gap in this area of research. This mixed-method research, particularly explanatory sequential design, hoped to provide an in-depth understanding of the learners' creative and critical thinking as catalyzed by graphic organizers.

RESEARCH QUESTIONS

1. How did the respondents perform in the pre-test and post-test?
2. How did the combination of the respondents' assessment and in-depth interviews provide a more comprehensive understanding of science graphic organizers effects on creative and critical thinking in terms of:
 - 2.1. inquiry, identification, exploration, and organization of information and ideas element;
 - 2.2. generation of ideas, possibilities, and actions element;
 - 2.3. reflection on thinking and processes element; and
 - 2.4. analysis, synthesis, and evaluation of reasoning and procedures element?
3. How significant was the relationship between the respondents' performance on the pre-test and post-test results and their assessment of the effects of science graphic organizers in creative and critical thinking?

MATERIALS AND METHODS

This part presents the research design, respondents, sampling technique, instrument, ethics and data collection procedures, and statistical tools utilized in this study.

Research Design

This study employed a mixed-method, particularly explanatory sequential design. Based on Creswell and Clark [18], the first phase of a sequential explanatory design begins with gathering and analyzing data quantitatively. The results of the first phase are connected to and explained by the results of qualitative data. The consequent qualitative stage of the research is performed to adhere to the quantitative part of the study. Below is the diagram presenting the explanatory sequential design utilized in this study.

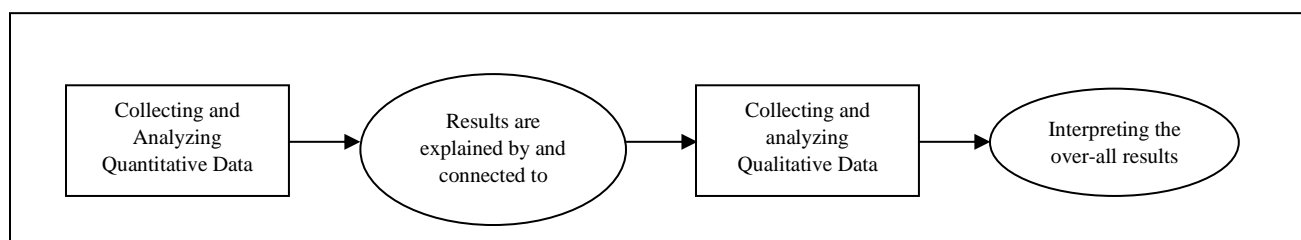


Figure 1. Explanatory Sequential Design.

Respondents

The study respondents were sixth-grade learners from the College of Teacher Education- Laboratory School of Batangas State University ARASOF Nasugbu, Academic Year 2020-2021. The respondents were selected through purposive total sampling. Of the 25 respondents, 14 or 56% were boys, and the remaining 44 % or 11 were girls. Sixth-grade learners were considered to be the respondents since they had a one-year experience of consistently using graphic organizers in their science class. The second phase of the research involved ten learners who were selected randomly for the purpose.

Research Instrument

The data-gathering instruments that were utilized in this study include the author-made survey questionnaire and interview guide. For the first phase, the questionnaire's items were adopted from the creative and critical thinking curriculum of the Australian curriculum [6]. It was administered to non-respondents to test the reliability of the instrument. The Cronbach's Alpha of 0.74, 0.80, 0.75, and 0.83 on inquiry, identification, exploration, and organization of information and ideas element; generation of ideas, possibilities, and actions element; reflection on thinking and processes element; and analysis, synthesis, and evaluation of reasoning and procedures element, respectively revealed that the questionnaire was reliable. The second part of the study employed an interview to gather the responses of the respondents in an in-depth manner.

Data Collection Procedures and Ethical Considerations

After the permission to conduct the principal was granted, the researcher secured assent and consent form from the respondents and their parents/ guardians, consequently. It was explained that the respondents were given autonomy to participate and answer the questionnaire and can cancel their participation if they decide to.

Further, participants did not receive compensation but were given a certificate of participation as a token of appreciation. It was also guaranteed that the respondents' data and responses were treated with confidentiality and are subjected to the provisions iterated in the Data Privacy Act of 2012. The respondents answered the survey through Google forms.

The result of the first phase was electronically processed and analyzed using SPSS. The second phase involved ten participants who were interviewed in Google Meet to verify the quantitative phase results. The researcher likewise informed the participants that the interview proceedings were recorded for documentation and transcription purposes. Responses were coded to establish themes that may support or explain the results of the first phase.

Statistical Treatment of Data

Weighted mean, standard deviation, ranking, and t-test were utilized to analyze the results of the study.

RESULTS AND DISCUSSION

The Results of Pre-test and Post-test

Table 1 highlights the pre-test and post-test results of the respondents.

Table 1. Results of Pre-test and Post-test

	Mean	SD	Mean Difference	Computed t-value	t-crit value	Sig (2-tailed)
Post-Test 1	11.88	1.764	3.56	25.007	2.064	.000
Pre-Test 1	8.32	1.796				
Post-Test 2	12.52	1.711	3.84	14.626	2.064	.000
Pre-Test 2	8.68	1.773				
Post-Test 3	13.12	1.666	4.08	18.941	2.064	.000
Pre-Test 3	9.04	1.904				
Post-Test 4	13.00	1.848	4.08	15.450	2.064	.000
Pre-Test 4	8.92	2.197				

The multiple pre-tests and post-test results exposed in Table 1 elucidates that differences in the mean of 3.56, 3.84, 4.08, and 4.08 respectively substantiated the effectiveness of graphic organizers in improving academic performance among learners. It further validates the results of a study that showed that learners' academic gains in Science statistically improved than the traditional way of delivering instruction [11].

According to Informant 2, 5, 7, and 10, graphic organizers help them easily understand different topics in Science. Informant 6 was quoted as saying, "use of graphic organizers in Science is helpful, and it gives me more fun experiences."

The computed t-values can support the findings above, which were 25.007, 14.626, 18.941, and 15.450, which were all greater when compared to the t-critical values of 2.064, significant at $p < 0.05$. The null hypothesis was then rejected; hence, there was a considerable difference in the respondents' results of the pre-test and post-test.

This result further established that graphic organizers are useful tools to improve understanding of concepts, retention, and mastery of contents confidently and actively indulge in graphic organizers [12].

Assessment on Creative and Critical Thinking

The results of respondents' assessment on the effects of graphics organizers on their creative and critical thinking in terms of inquiry, identification, exploration, and organization of information and ideas element; generation of ideas, possibilities, and actions element; reflection on thinking and processes element; and analysis, synthesis, and evaluation of reasoning and procedures element are presented in Table 2-5.

Assessment on Creative and Critical Thinking in Terms of Inquiry, Identification, Exploration, and Organization of Information and Ideas Element

The respondents' assessment of their creative and critical thinking in inquiry, identification, exploration, and organization of information and ideas influenced by graphic organizers is presented in Table 2.

Table 2. Inquiry, Identification, Exploration, and Organization of Information and Ideas Element

Indicators	WM	SD	Verbal Interpretation
1. Through graphic organizer, I can ask questions to expand my knowledge about the world	3.32	.748	Agree
2. Through graphic organizer, I can identify main ideas and select and clarify information from a range of sources	3.60	.645	Strongly Agree
3. Through graphic organizer, I can collect, compare and categorize facts and opinions found in a widening range of sources	3.64	.638	Strongly Agree
General Weighted Mean		3.52	(Strongly Agree)

The respondents were able to compile, contrast, and classify evidence and viewpoints included in an expanding variety of sources, as seen in the Table. This indicator received the highest weighted mean of 3.54 (SD= .638), which ranked first. The result is very significant since the ability to recognize factual data and information is essential in this information age, where there is a wide range of information.

Additionally, respondents strongly agreed that they were able to select and clarify information through graphic organizers. The

indicator received a weighted mean of 3.60 (SD= .645). It can be reflected in the words of Informant 6, saying, "Graphic organizers are a helpful learning tool for us to organize, clarify, or simplify complex information. They help us construct understanding through an exploration of the relationships between concepts".

Generally, the 3.53 weighted mean manifests the respondents' strong agreement on the idea that graphic organizers helped them collect and clarify factual information and formulating questions. Evidently, graphic organizers improved critical and creative thinking abilities and innovative learning among respondents [5].

Assessment on Creative and Critical Thinking in Terms of Generation of Ideas, Possibilities, and Actions Element

As perceived by the respondents, graphic organizers' effects in the generation of ideas, possibilities, and action elements are presented in Table 3.

Table 3. Generation of Ideas, Possibilities, and Actions Elements.

Indicators	WM	SD	Verbal Interpretation
1. Through graphic organizer, I can expand on general ideas to create new and imaginative combinations.	3.72	.542	Strongly Agree
2. Through graphic organizer, I can explore situations using creative thinking strategies to propose a range of alternatives	3.32	.900	Agree
3. Through graphic organizer, I can experiment with a range of options when seeking solutions and put ideas into action	3.36	.810	Strongly Agree
General Weighted Mean		3.47 (Agree)	

As deduced from Table 3, the participants shared their consensus on the concepts that they should build on specific principles to construct fresh and creative combinations through graphic organizers. In the quest for alternatives and suggestions, respondents were also able to play with a variety of choices. Using creative thought techniques to suggest alternatives, they were often able to discuss scenarios. These indicators received weighted means of 3.72 (SD= .542), 3.36 (SD= .810), and 3.32 (SD= .900), consecutively. Implicitly it can be deduced that this may help learners create and apply new ideas in particular contexts, see current issues in a new way, find alternate theories, and see or develop new connections that yield a positive result [7]. This is supported by Informant 3, which was quoted as saying, "They [graphic organizers] allow us to construct mental models that organize information. Graphic organizers that target critical and creative thinking are vehicles to help develop our cognitive abilities and provide formats for us to process our thinking about content". Similarly, Informant 4, 5, and 6 stated that graphics organizers help them map out their ideas and other lesson details.

In general, based on the results, it can be deduced that graphic organizers helped learners in generating ideas and possibilities that may lead to creative and imaginative actions. The computed general weighted mean of 3.47, which can be verbally interpreted as agree, supported the latter finding.

Assessment on Creative and Critical Thinking in Terms of Reflection on Thinking and Processes Element

Table 4 presents the respondents' assessment of graphic organizers' effects on reflection on thinking and processes elements.

Table 4. Reflection on Thinking and Processes Element.

Indicators	WM	SD	Verbal Interpretation
1. Through graphic organizer, I can reflect on, explain, and check the processes used to come to conclusions.	3.56	.821	Strongly Agree
2. Through graphic organizer, I can identify pertinent information in an investigation and separate it into smaller parts or ideas	3.52	.770	Strongly Agree
3. Through graphic organizer, I can transfer and apply information in one setting to enrich another	3.52	.770	Strongly Agree
General Weighted Mean		3.53 (Strongly Agree)	

The data from Table 4 represents the clear agreement of the respondents on the metrics of representing aspects of thought and processes. A calculated general weighted average of 3.53 was reported, which can be deduced verbally as strongly agree. Similarly, it can be construed that the respondents could reflect and explain the processes involved in coming to conclusions,

identify pertinent information to separate into smaller parts, and assimilate the information in a new context. These indicators received high weighted means of 3.56 (SD= .821) and 3.52 (SD= .770), respectively.

Informant 2 articulated that graphic organizers help in organizing thoughts and ideas. Similarly, according to Informant 1, "Graphic organizers can be beneficial tools in developing these critical thinking skills."

Assessment on Creative and Critical Thinking in Terms of Analysis, Synthesis, and Evaluation of Reasons and Procedures Element

Table 5 reflects the effects of graphic organizers in the analysis, synthesis, and evaluation of reasoning and procedures elements as perceived by the respondents.

Table 5. Analysis, Synthesis, and Evaluation of Reasoning and Procedures Element.

Indicators	WM	SD	Verbal Interpretation
1. Through graphic organizer, I can identify and apply appropriate reasoning and thinking strategies for particular outcomes	3.52	.770	Strongly Agree
2. Through graphic organizer, I can draw on prior knowledge and use evidence when choosing a course of action or drawing a conclusion	3.48	.770	Agree
3. Through graphic organizer, I can explain and justify ideas and outcomes	3.48	.770	Agree
General Weighted Mean		3.49 (Agree)	

It can be manifested from Table 5 that respondents were capable of defining and applying effective logic and thought techniques with the assistance of graphic organizers for specific outcomes. The highest weighted mean of 3.52 (SD= .770) was obtained by this measure, which can be translated verbally as highly agreed. This increases critical thinking. Informant 7 expressed that graphic organizers improve their ability to think critically in a more accurate way.

The respondents likewise agreed that they could use their prior knowledge to draw conclusions and justify its outcomes. Both indicators received a weighted mean of 3.47 (SD= .770). The findings are very significant, as it was claimed that critical thinking is at the heart of any academic practice [6].

As quoted from Informant 9, "It is easier to explain concepts when presented using graphic organizers." Suppose critical thinking among learners may be developed. In that case, they may learn to consider or construct an argument efficiently, utilize proof to substantiate the claim, draw appropriate conclusions, and use knowledge to solve problems. As a result, it may increase the holistic performance among learners.

Relationship Between Respondents' Post-test Results and Their Assessment on the Effects of Graphic Organizers on Their Creative and Critical Thinking

Table 6 shows the relationship between the respondents' post-test results and their assessment of graphic organizers' effects.

Table 6. Relationship Between Respondents' Post-test Results and Their Assessment on the Effects of Graphic Organizers on Their Creative and Critical Thinking.

Creative and Critical Thinking	Correlation Coefficient
Inquiry, Identification, Exploration, and Organization of Information and Ideas Element	0.572
Generation of Ideas, Possibilities, and Actions Element	0.422
Reflection on Thinking and Processes Element	0.393
Analysis, Synthesis, and Evaluation of Reasoning and Procedures Element	0.414

As elucidated in Table 6, the measured correlation coefficient of 0.572 with a qualitative definition of a moderate relationship was significant between "inquiry, identification, exploration, and organization of information, and ideas element" and the post-test findings of the respondents, because the estimated p-value of 0.003 is less than 0.05 significance level.

In viewing the relationship between "generation of ideas, possibilities, and actions element" and the post-test findings of the respondents, the computed correlation coefficient of 0.422 with a qualitative definition of a moderate relationship was shown

to be significant since the measured p-value of 0.036 is less than 0.05 level of significance.

Similarly, between "analysis, synthesis, and evaluation of reasoning and procedures element" and the respondents' post-test results, a moderate relationship was highlighted. The computed correlation coefficient of 0.414 was considered to be significant since the estimated p-value of 0.039 is less than 0.05.

However, between "reflection on thinking and processes element" and the respondents' post-test results, a low relationship was noted with a 0.393 correlation coefficient.

On delving deeper into the figures, it can be claimed that graphic organizers relatively contribute to learners' improvement of their creative and critical thinking. It strengthens the idea that as a graphical medium of communication that uses mental images to express thoughts and ideas and transmit context, graphic organizers stimulate students to use creative ways to think about knowledge and improve their critical thinking skills by promoting learning [10].

CONCLUSIONS AND RECOMMENDATIONS

The study results revealed that the respondents' post-test results improved statistically higher than their pre-test. Additionally, graphic organizers are useful tools to enhance understanding of concepts, retention, and content mastery. It was also found out that the statements of the informants further strengthened that graphic organizers have effects on the respondents' creative and critical thinking. Lastly, a moderate relationship was noted between the perceived effects of graphic organizers and the post-test results.

Based on the conclusions, the following recommendations were hereby endorsed: teachers may adapt the strategy in their classes to further improve creative and critical thinking and academic performance among learners. Future researchers may utilize various grade levels and other subject areas/courses in examining the effects of graphic organizers in developing pupils' creativity and critical thinking skills.

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