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VYTAUTO DIDŽIOJO UNIVERSITETO ŠVIETIMO AKADEMIJA

Graphic Organizers in an Online Learning Environment: Its Influence to Students' Cognitive Load and Knowledge Gain

Randel D. Estacio[1]**, Rosario F. Quicho**[2]**, Florante P. Ibarra**[3]**, Irene G. Bustos**[4]**, Leila M. Collantes**[5]**, Edwin D. Ibañez**[6]

[1] College of Education, Quezon City University, 673 Quirino Hi-way, San Bartolome, Novaliches, Quezon City, PH-1118 Philippines, randel.estacio@qcu.edu.ph
[2] College of Education, Central Luzon State University, Brgy. Bantug, Science City of Muñoz, Nueva Ecija, PH-3120 Philippines, rosario_quicho@clsu.edu.ph
[3] College of Education, Central Luzon State University, Brgy. Bantug, Science City of Muñoz, Nueva Ecija, PH-3120 Philippines, fpibarra@dotclsu.edu.ph
[4] College of Education, Central Luzon State University, Brgy. Bantug, Science City of Muñoz, Nueva Ecija, PH-3120 Philippines, irenebustos1220@gmail.com
[5] College of Education, Central Luzon State University, Brgy. Bantug, Science City of Muñoz, Nueva Ecija, PH-3120 Philippines, lcollantes@dotclsu.edu.ph
[6] College of Education, Central Luzon State University, Brgy. Bantug, Science City of Muñoz, Nueva Ecija, PH-3120 Philippines, edwindibanez@clsu.edu.ph

Annotation. The study investigates how graphic organizers influence the level of cognitive load and knowledge gained by the students at Quezon City University during the 1st semester, Academic Year 2021–2022 in an online learning environment. The one-group pretest-posttest design was utilized in the study. Results show that by using graphic organizers, students' level of cognitive load and knowledge gain have improved.

Keywords: *graphic organizers, online learning environment, cognitive load, knowledge gain, students' performance.*

Introduction

According to Sweller (2016), the amount of data that working memory can handle at any given time is referred to as "cognitive load". As teachers, it is critical to assess students' cognitive load in order to provide guidance on how we can effectively teach our students. According to Cognitive Load Theory (CLT), if a learner is unable to process knowledge in their working memory, that information will not be transferred to and stored in their long-term memory.

Furthermore, Sweller (2016) emphasized that working memory has a limited capacity, therefore, instructional methods should avoid overloading it with non-learning-related activities. According to CLT, working memory which primarily holds the information at a given time may be improved in two ways. One approach is to display the information in two distinct formats, such as graphical or audio, because our minds interpret visual and auditory information differently. Because human working memory sees established schema as a single item, the second approach is to give learning exercises that draw on the students' prior knowledge.

In 2016, Leahy and Sweller stressed that cognitive processing improves when students are given and combine visual representations of subject matter or concepts with verbal representations. The brain can process more information and develop connections with previously stored semantic concepts when visual and verbal representations are combined during learning, lowering the complexity and strain on working memory that would otherwise be imposed if both inputs were absent. Thus, in selecting appropriate instructional learning materials, it is highly emphasized to select those that will present visual and auditory information separately and trigger previous knowledge to establish schemas that will extend the students' working memory.

According to Chen and Wu (2015), visual organizational aids such as graphic organizers aid memory by improving the possibility of storing generated knowledge in the brain in a way that allows for more rapid and easy retrieval.

In addition, in a study conducted by Herrlinger et al. (2017) on the influence of visual representations on short- and long-term memory, graphical representations of material increased both short- and long-term memory. They stated that when students examine graphical images rather than reading or hearing the same abstract material, their short-term memory storage capacity and time are improved incrementally. Furthermore, Knoll et al. (2017) pointed out that integrating newly acquired knowledge and concepts with stored memory and problem solving can all be improved by employing external visual organizational semantic maps that resemble semantic memory.

According to recent studies, graphic organizers are any visual or graphic presentation that shows the relationships between facts, thoughts, and other ideas (Alhomaidan, 2015; Beydarani, 2015; Boykin, 2015; Casteleyn, et al., 2013; Kurniaman & Zufriady, 2019). As classroom teachers, the researchers used graphic organizers to probe students' understanding towards the lesson being presented and how they were able to connect the previous lessons or concepts to the present one. Also, the researchers find graphic organizers useful to determine students' misconceptions and use them as an avenue to correct their misconceptions. Further, the researchers used graphic organizers in presenting the concepts so that students could follow the flow of the presentation of each concept to be learned. The researchers also find it useful to summarize complex topics, especially science lessons or concepts, for a better understanding of the discussion.

Graphic organizers in the classroom have been thoroughly examined by educators all throughout the world. According to Ezzeldin (2017), utilizing graphic organizers to construct a structure of prior knowledge assists students to fine-tune their brains for the subject they are going to learn. In additionally, visual organizers provide cues that assist students in retrieving previously stored knowledge (Gunel et al., 2016; Nam & Cho, 2016; Thakur et al., 2017). As students studied by reviewing previously stored knowledge in a spatial fashion utilizing an earlier studied graphic organizer, they were able to recover material that had been committed to memory thanks to the graphic organizer. Because the stored information is connected with freshly learnt concepts, this leads to greater relational knowledge and comprehension (Moussa-Inaty et al., 2018).

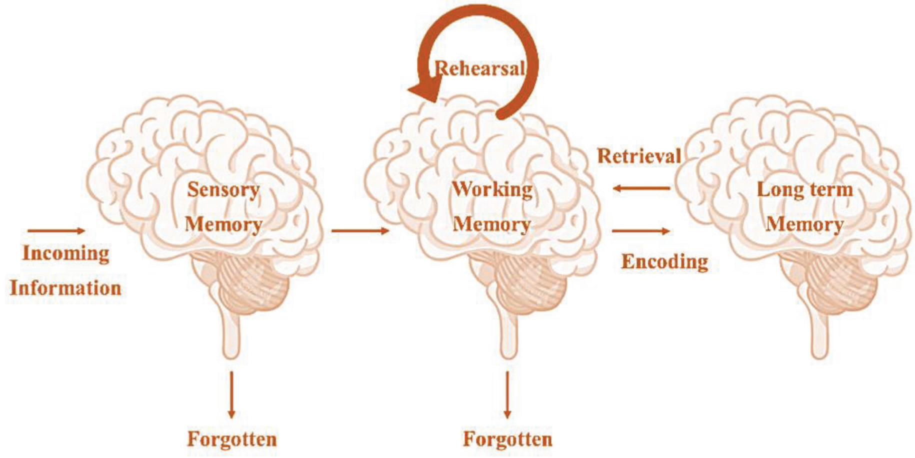
Studies have indicated that when prior knowledge is triggered by graphic organizers, comprehension of the topic improves with time. Students who learn content with visual organizers do not focus on generating accurate correlations or memorizing certain conceptual truths. Rather than that, the emphasis is on the linkages between facts in larger groups and the connections between ideas (Gunel et al., 2016; Nam & Cho, 2016; Thakur et al., 2017). Furthermore, according to Knoll et al. (2017), by splitting and organizing new stimuli into specified segments, graphic organizers are efficient educational aids for supporting students in refining their perception of stimuli. Once the seemingly different stimuli are merged together through the completion and reflection of a graphic organizer, the student will realize it is simpler to produce new information (Knoll et al., 2017; Koc-Januchta et al., 2017; Sweller, 2016; Rogowsky et al., 2015).

Theoretical framework

The theoretical grounds of the study include the Cognitive Load Theory produced by Sweller in 1988 and the Instrumental Conceptualism Theory developed by Bruner in 1960. The Cognitive Load Theory builds upon the widely established model of human information processing by Atkinson and Shiffrin (1968), presented in Figure 1. It characterizes the process as having three key parts: sensory memory, working memory, and long-term memory.

As discussed earlier, cognitive load refers to the amount of information that working memory can keep at one time. Working memory, which is responsible for storing information at a given time, can be improved in two ways, according to this theory. One option is to present the information in two different formats, such as graphical or auditory, because our brain processes visual and auditory information differently. Because our working memory treats and established schema as a single item, the second is to provide learning activities that draw on the students' existing knowledge. Working memory has a certain amount of space, thus instructional strategies should try to keep it from being overloaded with extra tasks that do not actually advance learning. Hence, when choosing appropriate instructional learning materials, it is critical to choose those that present visual and auditory information separately and trigger previous knowledge to establish schemas that will extend the students' working memory.

Figure 1
Model of Human Information Processing



On the other hand, Jerome Bruner's learning theory, which was developed in 1960, concentrated on how people use information to arrive at broader insights or understanding. According to him, learning is a cognitive process that entails three concurrent steps: (1) acquisition, which is the process of gathering new information that can either supplement or improve what is already known; (2) transformation, which is the manipulation of information to fit a new situation; and (3) evaluation, which is the process of determining whether the learned material has been appropriately modified.

The nature of the knowing process lies at the heart of Bruner's theory of learning, which he refers to as "instrumental conceptualism". Bruner believed that learning is a dynamic and interactive process, regardless of the form it takes. A learner is someone who actively chooses, organizes, memorizes, and transforms information as part of the knowledge-acquisition process. According to Bruner, an imaginative process of construction is necessary for mental processes like perception, idea acquisition, and reasoning. He believed that thinking is how we learn best. He continues by pointing out that in order for information to be used effectively by a student, it must be translated into his words.

Cognitive load theory and instrumental conceptualism theory helped the researchers visualized and conceptualized the study. Guided by the cognitive load theory and instrumental conceptualism theory, the researchers were able to clearly understand how graphic organizers influence the students' level of cognitive load and knowledge gain.

The Present Study

According to studies, using graphic organizers as instructional learning tools in the classroom can assist students in organizing, clarifying, or simplifying complex information or ideas. It can also assist students in building conceptual understanding by examining the connections between ideas, and graphic organizers – especially those made by teachers – can serve as a useful scaffold to support student learning (Chairilysha & Kurnia, 2018; Chong, 2017; Kansizoglu et al., 2017; Khamkhong, 2018; Kristiana & Hendriani, 2018; Kurniaman et al., 2018; Lu & Liu, 2015).

There are a few things that need to be clarified despite the success of employing graphic organizers in the classroom, which has been well demonstrated in numerous studies and is recommended as a useful educational strategy. For instance, the influence of graphic organizers in expanding the working memory or improving the amount of information that working memory can hold, or "cognitive load", and the knowledge gain of students, especially in science subjects like Science, Technology, and Society (STS).

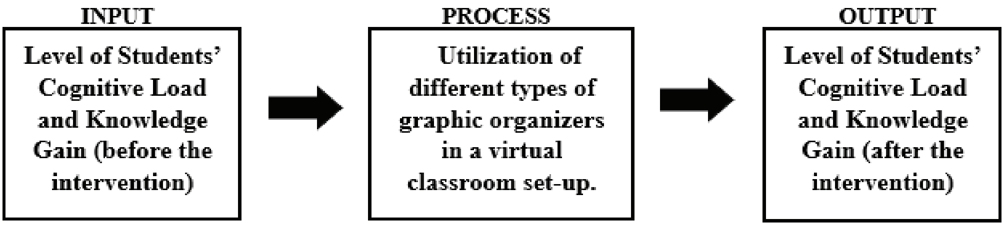
As a result, the researchers decided to investigate how the use of graphic organizers influences the cognitive load and knowledge gain of first-year students at Quezon City University (QCU) during the 1st semester, Academic Year (A.Y.) 2021–2022. The study attempts to describe the level of students' cognitive load and knowledge gain before and after receiving instructions using different types of graphic organizers and find out whether a difference in the level of students' cognitive load and knowledge gain exists before and after receiving instructions using different types of graphic organizers.

Taking into account the research objectives, the researchers hypothesize that "*there is no significant difference in the level of students' cognitive load and knowledge gain before and after receiving learning instructions using different types of graphic organizers*", which will be tested at the .05 level of significance.

Conceptual Paradigm of the Study

In addressing the pertinent problem under study, the researchers adopt the Input-Process-Output (IPO) paradigm. As illustrated in Figure 2, the input of the study includes the level of students' cognitive load and knowledge gain prior to the experiment. The process includes the utilization of different types of graphic organizers during online class. And lastly, determining the level of students' cognitive load and knowledge gain after the experiment serves as the output of the study to highlight how graphic organizers influence the level of students' cognitive load and knowledge gain.

Figure 2
Research Paradigm



Material and Methods

Research Locale

The study was conducted in Quezon City University (QCU) San Bartolome Campus during the 1st semester, A.Y. 2021-2022.

Figure 3
Map of Quezon City Showing the Location of Quezon City University Where the Study was Conducted

Participants of the Study

The study utilized first-year Bachelor of Science in Accountancy (BSA) college students from QCU as the primary participants. The general population of the study refers to all first-year BSA students at QCU during A.Y. 2021–2022. The BSA program has three sections of first-year students which consists of a total of 105 students.

The study adopted a convenient sampling technique to obtain the sample size. Due to the restrictions imposed by the Inter-Agency Task Force for the Management of Emerging Infectious Diseases in the Philippines (IATF) on movement and activities during the COVID-19 pandemic, the convenience sampling technique was far more appropriate in the conduct of the study.

The researchers utilized a total of thirty-five (35) first year BSA students, comprised of 12 males and 23 females. They were officially enrolled in the university during the 1st semester, A.Y. 2021–2022 and taking Science, Technology, and Society (STS) subject. Also, the participants were students and directly supervised by the primary researcher.

Research Design and Instruments

The study implemented the One Group Pretest-Posttest Design to realize its objectives. To determine the level of students' cognitive load and knowledge gain, the researchers used Self-rating Scale and a 90-item Multiple Choice test as instruments.

Self-rating Scale

Self-rating scales were frequently used to determine the global level of cognitive load. The Self-rating Scale for Cognitive Load used in the study was adopted from the Self Evaluation Scale made by the Social Work Department of the Texas A&M University-Commerce (TAMUC) and modified by the researchers to suffice the objectives of the study.

The self-rating scale was divided into three parts, namely: Intellectual Competencies (IC), Personal and Civic Responsibilities (PCR), Practical Skills (PS). Intellectual competency part encompasses both cognitive and non-cognitive attributes and it consists of five (5) items. The Personal and Civic Responsibility part includes items that focus on personal responsibilities and civic duties to support the community and the country. It includes nine (9) items. And lastly, the Practical Skills part includes five (5) items that focus on the practical aspects of something. This part involves real situations and events, rather than just ideas and theories.

The Self-rating Scale for Cognitive Load was made of structured statements or questions in a Likert format, where each choice is represented with the degree of agreement each respondent had on a given question. The Likert Scale used in this scale is given below:

Table 1
Likert Scale Used in the Self-Rating Scale for Cognitive Load

Scale	Verbal Interpretation	Description
5	High	The student has a high level of competence; extensive experience in the skill area.
4	Moderately high	The student has a moderately high level of competence; good experience in the skill area.
3	Average	The student has an average level of competence; some experience in the skill area.
2	Low	The student has a low level of competence; little experience in the skill area.
1	No level of competence	No experience in the skill area.

The self-rating scale's reliability is α = .825 which denotes that the instrument is good and therefore reliable, based on the interpretation values for Cronbach's alpha.

90-Item Multiple Choice Test

To determine the students' level of knowledge gain, a 90-item Multiple Choice test was used. The test was developed by the researchers based on the topics covered and the prepared Table of Specifications (TOS).

The test consists of fifteen (15) questions per topic, with a total of 90 items, and is worth one (1) point each. Each question requires a working knowledge of fundamental definitions and concepts ranging from simple to complex and were distributed into three cognitive levels based on a modified version of Bloom's taxonomy.

To ensure the validity of the instrument, the researchers enlisted the assistance of five selected Science faculty members in the Department of Mathematics and Science of Quezon City University to evaluate the instrument's content in terms of its format, language used, and questions that assess the desired objectives. Their suggestions and comments were properly documented and incorporated in the second version of the survey questionnaire.

The Cronbach alpha value of the test is α = .753 which denotes that the instrument is acceptable and therefore reliable, based on the interpretation values for Cronbach's alpha.

Procedure

The primary researcher asked the approval of the Quezon City University Office of the Vice President for Research, Extension, Planning, and Linkages (QCU-REPL) to conduct the study. Upon approval, the primary researcher emailed the Informed Consent Letter and Informed Consent Form to the prospected students via Google Forms.

The students accomplished and signed the Informed Consent Forms and were returned to the primary researcher. After which, the formal experiment began immediately.

The experiment lasted for six (6) weeks. It started last on the 9th of October, 2021 and concluded on the 13th of November, 2021.

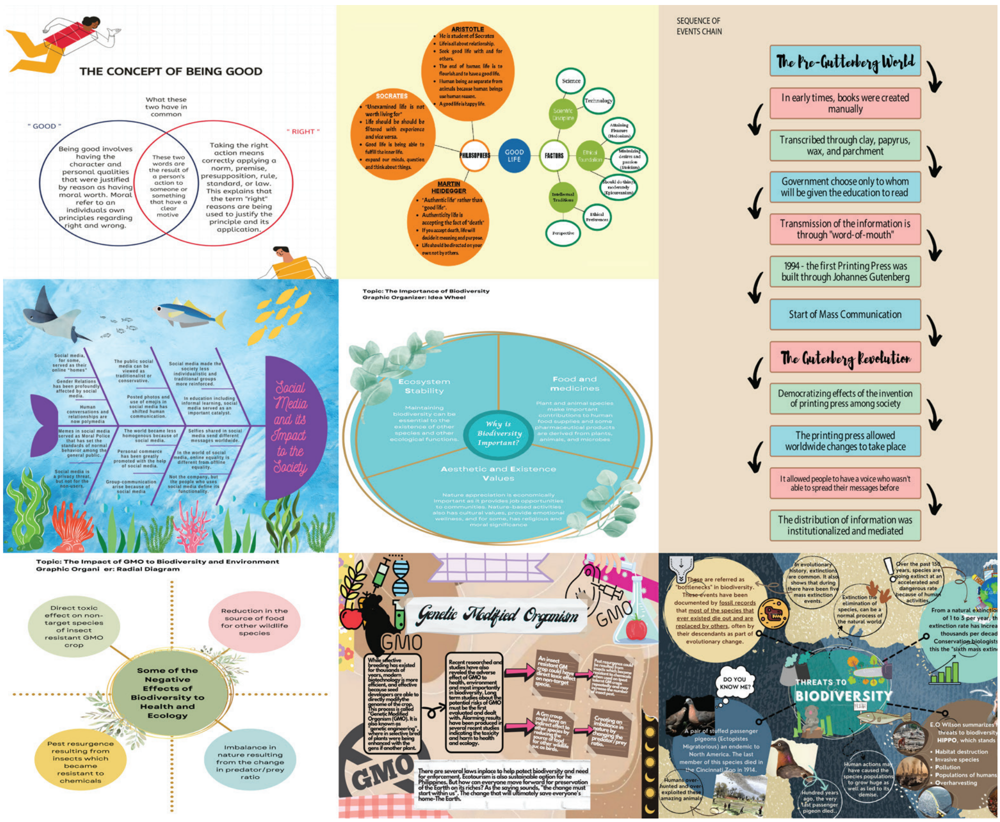
The research instruments (Self-rating Scale and 90-Item Multiple Choice Test) were given to the students during the first week of the experiment.

In the duration of the study, the students were taught the following topics: Science and Technology and Nation Building; The Human Flourishing; The Good Life; The Information Age (Gutenberg to social media); Biodiversity and Health Society; and Genetically Modified Organisms: Science, Health, and Politics.

The students received online lecture-discussions on the said topics with the addition of several Graphic Organizers in various parts of the session such as motivation, student activities (synchronous and asynchronous), formal lecture-discussion, topic summary, assessment, and assignment. Sample graphic organizers used in the study are presented in Figure 4.

Figure 4

Sample Graphic Organizers Used in the Study



Graphic organizers were developed by the primary researcher using Canva and Microsoft Publisher in presenting key concepts during motivation, formal lecture-discussion, and topic summary. For students' activity, assessment, and assignment (off-line), the prepared blank graphic organizers were given to students and can be accessed via Canva and Google Docs. The students had to submit their answered graphic organizers in the submission folder found in Google Classroom for checking and evaluation. Student's graphic organizers were returned to them with teacher's comments or annotation.

As a culminating activity on the sixth week of the experiment, the self-rating scale and the 90-item multiple choice test were given to the students with the supervision of the primary researcher to determine the level of students' cognitive load and knowledge gain after the experiment.

Data Analysis

The study used statistical measures to make inferences, interpretations, conclusions, and generalizations. Descriptive statistics such as frequency, percentage, mean, and standard deviation were used to interpret the students' performances, cognitive load, knowledge gain, and self-efficacy. A Likert scale was used to describe the results and supplement the interpretation derived from the collected data.

The difference in level of students' cognitive load before and after using graphic organizers was determined using the Wilcoxon signed rank test, while a paired sample t–test at 0.05 level of significance was used to determine the difference between the level of students' knowledge gain before and after using graphic organizers. The collected data were processed using IBM SPSS Statistics version 22 statistical software.

Results

Students' Level of Cognitive Load and Knowledge Gain Before and After the Experiment

Table 2 shows that the over-all cognitive load of the students before receiving learning instructions that utilize different types of graphic organizers. It can be gleaned that students' cognitive load before the experiment is described as "*Average*" level of competence ($M = 3.05$, $SD = 0.18$).

Table 2
Level of Students' Cognitive Load Before the Experiment

	Mean	SD	Description
Intellectual Competencies			
1. Higher levels of comprehension (textual, visual, etc.).	2.91	0.82	Average
2. Proficient and effective communication (writing, speaking, and use of new technologies).	3.09	0.78	Average
3. Understanding of basic concepts across the domains of knowledge.	2.91	0.85	Average
4. Critical, analytical, and creative thinking.	3.23	0.81	Average
5. Application of different analytical modes (quantitative and qualitative, artistic and scientific, textual and visual, experimental, observation, etc.) in tackling problems methodically.	3.00	0.80	Average
Mean	**3.00**	**0.57**	**Average**
Personal and Civic Responsibilities			
1. Appreciation of the human condition.	3.00	0.80	Average
2. Capacity to personally interpret the human experience.	3.29	0.86	Average
3. Ability to view the contemporary world from both Philippine and global perspectives.	2.97	0.82	Average
4. Self-assuredness in knowing and being a Filipino.	3.11	0.87	Average
5. Capacity to reflect critically on shared concerns and think of innovative, creative solutions guided by ethical standards.	3.00	0.80	Average
6. Ability to reflect on moral norms/imperatives as they affect individual society.	3.06	0.80	Average
7. Ability to appreciate and contribute to artistic beauty.	3.09	0.92	Average
8. Understanding and respect for human rights.	2.74	0.85	Average
9. Ability to contribute personally and meaningfully to the country's development.	3.20	0.76	Average
Mean	**3.05**	**0.28**	**Average**
Practical Skills			
1. Working effectively in a group.	3.06	0.80	Average
2. Application of computing and information technology to assist and facilitate research.	3.09	0.74	Average
3. Ability to negotiate the world of technology responsibly.	3.11	0.72	Average
4. Problem-solving (including real-world problems).	2.80	0.76	Average
5. Basic work-related skills and knowledge.	3.26	0.85	Average
Mean	**3.06**	**0.31**	**Average**
Over-all Mean	**3.05**	**0.18**	**Average**

Data revealed that in terms of intellectual competencies, students said that their cognitive load is "*Average*" with a computed mean value of 3.00 and a standard deviation of 0.57 before the utilization of graphic organizers. Further, Table 2 revealed that the students agreed that they have an "*Average*" level of competence when it comes to personal and civic responsibilities with a computed over-all mean value of 3.05 and a standard deviation of 0.28 before utilizing graphic organizers. Lastly, in terms of practical skills, students described their competence as "*Average*" before using graphic organizers with computed over-all mean value of 3.06 and a standard deviation of 0.31. This can be construed that the cognitive load of the students is not affected by any instructional learning materials or interventions prior to the conduct of the experiment.

After the students were exposed to learning instructions that utilize different types of graphic organizers, the over-all cognitive load of the students is described as "*Average*" with a computed over-all mean value of 3.26 and a standard deviation of 0.13 as presented in Table 3. Particularly, the students describe their personal and civic responsibilities (M = 3.29, SD = 0.19), practical skills (M = 3.26, SD = 0.26), and intellectual competencies (M = 3.22, SD = 0.24) as "*Average*".

Table 3

Level of Students' Cognitive Load After the Experiment

	Mean	SD	Description
Intellectual Competencies			
1. Higher levels of comprehension (textual, visual, etc.).	3.17	0.45	Average
2. Proficient and effective communication (writing, speaking, and use of new technologies).	3.06	0.48	Average
3. Understanding of basic concepts across the domains of knowledge.	3.34	0.54	Average
4. Critical, analytical, and creative thinking.	3.34	0.64	Average
5. Application of different analytical modes (quantitative and qualitative, artistic and scientific, textual and visual, experimental, observation, etc.) in tackling problems methodically.	3.20	0.58	Average
Mean	**3.22**	**0.24**	**Average**
Personal and Civic Responsibilities			
1. Appreciation of the human condition.	3.43	0.61	Moderately High
2. Capacity to personally interpret the human experience.	3.41	0.69	Moderately High
3. Ability to view the contemporary world from both. Philippine and global perspectives.	3.20	0.47	Average
4. Self-assuredness in knowing and being a Filipino.	3.26	0.56	Average

5. Capacity to reflect critically on shared concerns and think of innovative, creative solutions guided by ethical standards.	3.26	0.74	Average
6. Ability to reflect on moral norms/imperatives as they affect individual society.	3.06	0.68	Average
7. Ability to appreciate and contribute to artistic beauty.	3.23	0.69	Average
8. Understanding and respect for human rights.	3.29	0.62	Average
9. Ability to contribute personally and meaningfully to the country's development.	3.46	0.51	Moderately High
Mean	**3.29**	**0.19**	**Average**
Practical Skills			
1. Working effectively in a group.	3.26	0.51	Average
2. Application of computing and information technology to assist and facilitate research.	3.29	0.57	Average
3. Ability to negotiate the world of technology responsibly.	3.31	0.63	Average
4. Problem-solving (including real-world problems).	3.09	0.70	Average
5. Basic work-related skills and knowledge.	3.37	0.60	Average
Mean	**3.26**	**0.26**	**Average**
Over-all Mean	**3.26**	**0.13**	**Average**

Based on the results, after utilizing graphic organizers, students still agreed that the level of their cognitive load is "*Average*". This means that even though they experienced using graphic organizers in STS lessons, the level of information that they stored in their working memory is still on the average.

However, it should be emphasized that after employing graphic organizers, their cognitive load was reported to be "*Moderately High*" in terms of their potential to individually and meaningfully contribute to the country's growth, understand the human situation, and directly interpret human experience. This is expected since the primary goal of the subject STS is to develop professionally competent, humane, and moral graduates.

In comparing the over-all means before (M = 3.05, SD = 0.18) and after (M = 3.26, SD = 0.13) the exposure to various types of graphic organizers, it can be gleaned that there is still an increase in value despite of both descriptions falling below instead under average. The students' responses to the self-rating scale after the exposure to graphic organizers are similar with one another as evident by the lower value of the standard deviation compared with the standard deviation of the responses before the use of graphic organizers.

On the other hand, Table 4 presents the level of students' knowledge gain in the subject STS before and after receiving learning instructions using various types of graphic organizers in an online classroom setting.

The over-all mean of the test before receiving instructions and learning using various types of graphic organizers is 34.83 and interpreted as "*Fail*", with a standard deviation of 6.43. Specifically, Table 4 shows that a total of twenty-two out of thirty-five students or 62.86 percent got a score that is less than 37 points which is interpreted as "*Fail*". Only eleven or 31.43 percent of the students got a score between 37 to 45 points and described as "*Improve*", while two students got a score between 46 to 54 which is considered as "*Pass*".

In contrast, an improvement on students' knowledge gain is seen after receiving learning instructions using various types of graphic organizers. The computed over-all mean of the test after receiving learning instructions using various types of graphic organizers is 45.40 (SD = 6.44) and interpreted as "*Pass*". In detail, majority or 51.43 percent of the students got an improve score ranging from 37 to 45 points, while 28.57 percent of the students got a passing score between 46 to 54 points which is interpreted as "*Improve*", and 17.14 percent of the students got a "*Moderate*" score which is between 55 to 63 points. Only one student got a score that is less than 37 points which is interpreted as "*Fail*".

Table 4

Level of Students' Knowledge Gain Before and After the Experiment

Range of Scores	Description	Before		After	
		Frequency	Percentage	Frequency	Percentage
82 – 90	Excellent	0	0	0	0
73 – 81	Very Good	0	0	0	0
64 – 72	Good	0	0	0	0
55 – 63	Moderate	0	0	6	17.14
46 – 54	Pass	2	5.71	10	28.57
37 – 45	Improve	11	31.43	18	51.43
Less than 37	Fail	22	62.86	1	2.86

Difference in the Level of Students' Cognitive Load Before and After the Experiment

To ascertain whether the level of cognitive load (CL) of the students differed before and after the experiment, the Friedman test was performed and to examine where the difference occurred, a Wilcoxon signed rank test was conducted. The results of the tests are presented in Table 5 and Table 6.

Table 5

Friedman Test Result on the Level of Students' Cognitive Load Before and After the Experiment

	N	χ^2	df	*P*
(CL before) – (CL after)	35	35.00	1	.000*
(IC before) – (IC after)	35	31.00	1	.000*
(PCR before) – (PCR after)	35	35.00	1	.000*
(PS before) – (PS after)	35	31.11	1	.000*

Data revealed that there is a statistically significant difference in the level of students' cognitive load before and after receiving learning instructions with graphic organizers, $\chi^2(2) = 35.00$, $p = 0.000$. Also, in comparing the students' cognitive load in terms of perceived intellectual competencies, $\chi^2(2) = 31.00$, $p = 0.000$; personal and civic responsibilities, $\chi^2(2) = 35.00$, $p = 0.000$; and practical skills, $\chi^2(2) = 31.11$, $p = 0.000$ before and after the experiment, a significant difference was found.

Furthermore, to support the results of the Friedman test, the Wilcoxon signed rank test result is presented in Table 6. Data showed that the level of cognitive load of the students before receiving learning instructions with graphic organizers is significantly different from the level of students' cognitive load after receiving learning instructions with graphic organizers, $z = -5.163$, $p < 0.05$, with a large effect size ($r = -0.617$).

Table 6

Difference in the Level of Students' Cognitive Load Before and After the Experiment

	Negative ranks			Positive ranks			Test Statistics		
	N	Mean rank	Sum of ranks	N	Mean rank	Sum of ranks	Ties	Z	*p*
(CL before) – (CL after)	0	.00	.00	35	18.00	630.00	0	-5.163[a]	.000*
(IC before) – (IC after)	0	.00	.00	31	16.00	496.00	4	-4.880[a]	.000*
(PCR before) – (PCR after)	0	.00	.00	35	18.00	630.00	0	-5.168[a]	.000*
(PS before) – (PS after)	1	1.50	1.50	34	18.49	628.50	0	-5.150[a]	.000*

* Indicates statistically significant change

[a] Based on negative ranks

Moreover, Table 5 revealed that a Wilcoxon signed rank test revealed a statistically significant difference in the level of students' intellectual competencies (IC) before and after receiving learning instructions using graphic organizers, z = -4.880, $p < 0.05$, with a large effect size (r = -0.583). The mean score of students' intellectual competencies increases before (M = 3.00) and after (M = 3.22) receiving learning instructions with graphic organizers.

In terms of personal and civic responsibilities (PCR), Table 5 divulged that a Wilcoxon signed rank test declared a statistically significant difference in the level of students' personal and civic responsibilities z = -5.168, $p < 0.05$, with a large effect size (r = -0.618). The mean score of students' intellectual competencies increases before (M = 3.05) and after (M = 3.29) receiving learning instructions with graphic organizers.

And lastly, in terms of practical skills (PS), Table 5 revealed that a Wilcoxon signed rank test revealed a statistically significant difference in the level of students' practical skills, z = -5.150, $p < 0.05$, with a large effect size (r = -0.616). The mean score of students' intellectual competencies increases before (M = 3.06) and after (M = 3.26) receiving learning instructions with graphic organizers.

The findings indicate that learning instructions with various types of graphic organizers have a direct effect on improving the cognitive load of the students under study. Furthermore, when comparing the overall means before and after exposure to various types of graphic organizers, a significant difference in the means can be discerned. This difference indicates that graphic organizers assist the students in organizing their thoughts and the concepts presented to them into a single concrete construct. As a result, their working memory is freed up and they can accept new ideas or information.

Difference in the Level of Students' Knowledge Gain Before and After the Experiment

The difference between the level of students' knowledge gain before and after receiving learning instructions with graphic organizers is presented in Table 7. Results show that the scores of the students before the experiment (M = 34.83, SD = 6.43) is significantly different from their scores after the experiment (M = 45.40, SD = 6.44), t(68) = -6.875, $p < 0.05$.

Table 7

Difference in the Level of Students' Knowledge Gain Before and After the Experiment

	Mean	SD	df	t	p-value
Before	34.83	6.43	68	-6.875*	.000
After	45.40	6.44			

The data indicate that learning instructions using various types of graphic organizers have an explicit effect on the students' knowledge gain. This is because complex topics presented through graphic organizers encourage students to think in terms of abstract concepts or symbolic reasoning, which is appropriate for their age and stage of intellectual development. Additionally, it was observed that graphic organizers assisted students in organizing their thoughts when responding to formative assessment questions, and thus, it was expected that the results of the examination given to them to assess their level of knowledge gain would yield positive results.

Furthermore, it was observed that when graphic organizers were used in class, they aided the students in deductively arriving at a concept, allowing them to gradually acquire higher-level thinking ability. By connecting pertinent ideas with graphic organizers, students can clearly organize their thoughts and ideas, enabling them to analyze, interpret, and synthesize given information. This is demonstrated through their outputs, which require them to create their own graphic organizers following each topic.

Discussion and Conclusion

In terms of students' level of cognitive load, an increase in the over-all computed mean value was evident after the students were exposed to learning instructions with graphic organizers. This result can be attributed to the fact that graphic organizers help the students organize their thoughts and the concepts presented to them in a single concrete construct. Thus, unloading their working memory and allowing it to accept new ideas or information.

The findings show that the respondents' working memory is averagely kept and updated with new information. With this, graphic organizers allow the students to process new information or concepts and store them in their working memory, as graphic organizers help them summarize and organize complex ideas and eliminate discrete ideas or concepts.

It can be highlighted that prior to the use of graphic organizers, students believed that they had average level of competence in understanding the basic concepts across the domains of knowledge and the topics discussed, however, after using graphic organizers, there is an increase in the level of competence of the students, as seen in the computed mean values before and after the experiment.

In terms of personal and civic responsibilities, it can be noted that prior to the experiment, students had an average level of competence when it comes to understanding and respecting of human rights, and appreciating of human condition, but after being exposed with lessons that utilized graphic organizers, it can be seen that there is an increase in the level of students' competence as manifested in the computed mean values before and after the experiment. This can be attributed to the fact that the topics discussed during the experiment include the concept of human flourishing, the concept of good life, and how science and technology are integrated in the concepts of information technology, biodiversity, and health society, and issues and concerns about genetically modified organisms. When it comes to practical skills, students believed that they have average level of competence when it comes to problem-solving, particularly in real-world problems. But after being exposed with various types of graphic organizers, students' level of competence increased as revealed by the computed mean before and after the experiment.

However, the "*Average*" results on the level of students' cognitive load after the experiment might be affected by the length or duration of the study, according to the results of the study conducted by Leppink and Van den Heuvel in 2015, cognitive load of the students is directly influenced by the time of exposure to the knowledge or information.

Findings also show that, when graphic organizers trigger prior knowledge, comprehension of the content improves over time. Students can fine-tune their brains for the content they are about to learn by using graphic organizers to develop a structure of prior knowledge. Furthermore, the result confirms the notion that visual organizers provide cues to help students recall previously stored knowledge. The stored data is linked to newly learned concepts, resulting in improved relational understanding and knowledge. Also, the findings revealed that graphic organizers are helpful in scaffolding students' cognitive load.

Based on the results, it is clear that graphic organizers improve students' cognitive load by helping students organize concepts, their ideas, thoughts, and acquired information into single concrete idea. Graphic organizers are also seen as a useful tool that can help students in eliminating irrelevant information found in their working memory to entertain new information or concepts that are useful in analyzing present situation, problem, or issue, and to construct relevant information. As a result, the null hypothesis, which claimed that there was no substantial difference between students' cognitive loads before and after receiving instructions and using different kinds of graphic organizers, is rejected.

On the other hand, in terms of the level of students' knowledge gain, data revealed that there is an improvement in the level of students' knowledge gain after utilizing various types of graphic organizers. By analyzing the results of the test, it can be highlighted that prior to the experiment, students got a lower score particularly on items that are categorized as understanding and application level and higher mental process level. However, after using the graphic organizers, the students were able to answer questions that fall under the understanding and application level and higher mental process level.

Due to their age and stage of intellectual development, students are able to think in terms of abstract concepts or symbolic reasoning when complex topics are presented using graphic organizers. This explains why they are now able to answer questions or complete tasks that were previously difficult for them. Because students can organize and summarize information in their working memory with the aid of graphic organizers, and eventually entertain and process new information, they will be able to successfully respond to knowledge-gaining test questions. This result is constrained by the total number of students studied, the topics covered, and the length of the study.

It was also observed that during the experiment, graphic organizers helped the students organize their thoughts in answering the questions given to them during formative assessment. In addition, the researchers also observed that when graphic organizers are used in class, they help the students arrive at a concept inductively which enables them to acquire gradually higher-level thinking ability. This is revealed in their outputs that require them to develop their own graphic organizers after each topic.

The improvement of students' knowledge gain after utilizing graphic organizers revealed that graphic organizers are useful in promoting acquisition of knowledge and meaningful learning experience in class. Therefore, it can be argued that when graphic organizers are used effectively throughout the teaching and learning process, they can help students acquire new knowledge and allow them to organize their present thoughts and ideas and connect them to their previous ideas to come up with one single concrete idea. Thus, the null hypothesis that there is no significant difference in the level of knowledge gained by students before and after receiving instructions and learning using various types of graphic organizers is rejected.

The results on the increase in students' level of knowledge gain is congruent with the results of the study conducted by Rogowsky et al. in 2015 which highlighted that a graphic organizer in the form of a concept map can be a reliable indicator of an individual's understanding of the relationships between concepts within a topic area. Additionally, Rogowsky et al. (2015) asserted that if graphic organizers are created to fit students' developmental and cognitive demands, they will have little to no trouble completing them independently, enhancing their information acquisition. According to Sweller (2016) and Koc-Januchta et al. (2017), graphic organizers also help students recall, amplify, and refine their existing schemata as well as create new schemata.

Based on the significant findings and conclusions of the study, the researchers recommend that teachers should utilize various types of graphic organizers in improving students' level of cognitive load and knowledge gain. Furthermore, graphic organizers should be used and maximized inside and outside the classroom, especially in teaching science concepts in an online learning environment. Teachers should take advantage of graphic organizers as instructional learning materials to improve students' learning. And lastly, educational leaders and school administrators should support the development of instructional learning materials and their utilization, by providing seminars and workshops to teachers and instructional developers about instructional learning material development, selection, and modification.

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Grafiniai vaizdiniai internetinėje mokymosi aplinkoje: įtaka studentų kognityviniam krūviui ir žinioms

Randel D. Estacio[1], **Rosario F. Quicho**[2], **Florante P. Ibarra**[3], **Irene G. Bustos**[4], **Leila M. Collantes**[5], **Edwin D. Ibañez**[6]

[1] Edukologijos kolegija, Kesono universitetas, Kvirino greitkelis 673, San Bartolome, Novaliches, Kesono miestas, PH-1118 Filipinai, randel.estacio@qcu.edu.ph

[2] Edukologijos koledžas, Centrinis Lusono valstijos universitetas, Batango rajonas, mokslo miestas Munozas, Naujoji Ecija, PH-3120 Filipinai, rosario_quicho@clsu.edu.ph

[3] Edukologijos koledžas, Centrinis Lusono valstijos universitetas, Batango rajonas, mokslo miestas Munozas, Naujoji Ecija, PH-3120 Filipinai, fpibarra@dotclsu.edu.ph

[4] Edukologijos koledžas, Centrinis Lusono valstijos universitetas, Batango rajonas, mokslo miestas Munozas, Naujoji Ecija, PH-3120 Filipinai, irenebustos1220@gmail.com

[5] Edukologijos koledžas, Centrinis Lusono valstijos universitetas, Batango rajonas, mokslo miestas Munozas, Naujoji Ecija, PH-3120 Filipinai, lcollantes@dotclsu.edu.ph

[6] Edukologijos koledžas, Centrinis Lusono valstijos universitetas, Batango rajonas, mokslo miestas Munozas, Naujoji Ecija, PH-3120 Filipinai, edwindibanez@clsu.edu.ph

Santrauka

Šiame straipsnyje nagrinėjama, kokią įtaką grafinių vaizdinių naudojimas mokymosi metu daro Kesono miesto universiteto (angl. *QCU*) pirmojo kurso buhalterinės apskaitos bakalauro studijų programos studentų kognityviniam krūviui ir žinių lygiui internetinėje mokymosi aplinkoje per pirmąjį 2021–2022 mokslo metų semestrą. Tyrimo imties dydžiui gauti taikytas patogiosios atrankos metodas. Tyrime dalyvavo trisdešimt penki (35) pirmojo kurso buhalterinės apskaitos studentai: 12 vaikinų ir 23 merginos. Jie I semestre studijavo dalyką „Mokslas, technologijos ir visuomenė“ (angl. *STS*). Šiame tyrime aprašomas studentų kognityvinis krūvis ir žinių įgijimas bei jų skirtumai prieš ir po intervencijos, kai studentai gavo mokymosi instrukcijas, kuriose naudojami skirtingų tipų grafiniai vaizdiniai, skirti mokomajam dalykui „Mokslas, technologijos ir visuomenė“ (angl. *STS*). Siekdami nustatyti studentų kognityvinio krūvio lygį ir žinių lygį, tyrėjai kaip instrumentus naudojo įsivertinimo skalę ir 90-ties klausimų testą su keliais atsakymų variantais. Rezultatai rodo, kad grafiniai vaizdiniai teigiamai veikia studentų kognityvinį krūvį, nes padeda studentams susisteminti sąvokas, mintis ir gautą informaciją į vieną konkrečią idėją. Grafiniai vaizdiniai taip pat vertinami kaip naudinga priemonė, kuri gali padėti studentams pašalinti iš jų darbinės atminties nereikšmingą informaciją, kad būtų galima įtraukti naują informaciją ar sąvokas, naudingas analizuojant esamą situaciją, problemą ar klausimą. Remiantis reikšmingais tyrimo rezultatais ir išvadomis, dėstytojams rekomenduojama naudoti įvairių tipų grafinius vaizdinius, kad būtų padidintas studentų pažintinio krūvio lygis ir pagerintas žinių įgijimas.

Esminiai žodžiai: *grafiniai vaizdiniai, internetinė mokymosi aplinka, kognityvinis krūvis, žinių įgijimas, studentų pasiekimai.*

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