International Journal of Science, Technology, Engineering and Mathematics
Volume 2 Issue 4 December 2022
DOI: https://doi.org/10.53378/352926

Dual Coding Cognition in Devising Infographics for an Enhanced Students' Scientific Knowledge

[1]Jocelyn Dogomeo & [2]John Vincent Aliazas

Abstract

The goal of science education is to increase students' scientific literacy, which includes the acquisition of scientific knowledge, to become informed and active citizens who can make decisions that influence their health, environment, or society. In line with this, the study sought to determine the efficacy of using infographics in enhancing the scientific knowledge of 160 grade 8 students in Alaminos Laguna. Furthermore, it investigates the students' dual coding cognition as inputs to developing the infographic materials. It also evaluates students' preferences for static and animated infographics, and evaluators' ratings of the created infographics. This study is descriptive developmental in nature, as it employs survey questionnaires to assess students' dual coding cognition, students' preference for static versus animated infographics, and experts' ratings on the designed infographic materials. It also creates, designs, and assesses infographic learning materials in accordance with the criteria established to be effective. The results showed that students' dual coding cognition in terms of verbal and imagery is both "practiced" and that both infographics were "preferred" by the students. The static infographics received an "excellent" score from the expert raters, while animated infographics received a "very good" rating. The result generated showed infographics enhanced learners' performance and demonstrated a substantial difference between their pre-and post-test scores in terms of scientific knowledge. The findings indicate that using infographics to increase students' scientific knowledge and academic performance was indeed beneficial.

Keywords: *Animated, dual coding cognition, infographics, mental imagery, scientific knowledge, static*

Article History:

***Received**: August 8, 2022* ***Revised**: September 12, 2022*
***Accepted**: September 19, 2022* ***Published online**: October 3, 2022*

Suggested Citation:
Dogomeo, J. & Aliazas, J. (2022). Dual Coding Cognition in Devising Infographics for an Enhanced Students' Scientific Knowledge. *International Journal of Science, Technology, Engineering and Mathematics*, Volume 2 Issue 4, pp. 1 - 17. DOI: https://doi.org/10.53378/352926

About the authors:
[1]Corresponding Author. Teacher 3, Alaminos Integrated National High School, DepEd-Laguna, Philippines
[2]Assistant Professor 3, College of Teacher Education, Laguna State Polytechnic University, Philippines

1. Introduction

For decades, scientific literacy has been a desired outcome in science education. It focuses on the acquisition and application of scientific knowledge that will impact the student's personal decision-making and public participation in science. Scientific knowledge is an important component of scientific literacy (Eilks & Hofstein, 2017). However, lack of scientific knowledge leads to poor development of scientific literacy skills which not only hamper students' personal decision making but also impedes scientific and technological advancement and country's excellence (Zainuri et al., 2020).

In 2019, the Philippine educational system was put into spotlight as the result of Trends in International Mathematics and Science Study 2019 (TIMSS) revealed that 13% of Filipino students were on the low benchmark, which means they had "limited understanding of scientific concepts and limited knowledge of foundational science facts," while 87% did not even reach this level. Prior to this, the Philippines placed second worst in the world in science in the 2018 Program for International Student Assessment (PISA) as it received a score of 357 in science, which was lower than the average of the Organization for Economic Cooperation and Development's participating countries (Rappler, 2020).

This decline in student performance is reflected in the School Level of Progress and Achievement Report of the Junior High School students in Alaminos Laguna in the school year 2020-2021. Only 11.07% of the 1,770 students received an outstanding grade of 90-100, and only 16.84% received a very satisfactory grade of 85-89, while most students received a satisfactory grade of 80-84, which is 35.76% and a fairly satisfactory grade of 75-79, which is 36.33% of the total population. Given this situation, it is imperative to exert maximum efforts to deal with these concerns among Filipino learners. One of the innovative ways to improve academic performance is to introduce strategies such as infographics in teaching science concepts.

According to Parkinson (2016), infographics combine brief explanatory text with visual symbols to convey information in an appealing and understandable way. The numerous representations that can be employed, such as bar graphs, pie charts, histograms, zoom boxes, tree diagrams, line charts, icons, and even images, enhance the impact of infographics. Feldman, et al. (2022) add that infographics facilitates the association and creation of mental representations of words that help improve learning and memory performance in both children and adults. Similarly, Guarnera et al. (2019) state that creating mental images is a common

technique that are used to improve memory and comprehension. It is a process of constructing mental images when learning new information for better recall. However, despite the promising features of these infographics as innovative instructional tools, there is insufficient research to prove their effectiveness in improving the academic performance of Filipino students in science. This gap in the research literature is addressed in this study. As such, this study investigates significant difference between the pretest and posttest scores of students in terms of scientific knowledge before and after the utilization of infographics learning tools.

2. Literature review

2.1 Infographics in education

Several researchers explored the instructional relevance of infographics in different subjects and areas. Lyra et al. (2016) investigated the effectiveness of instructional infographics in the classroom and discovered that infographics improved long-term information retention significantly more than traditional textbooks. Similarly, Sriphrom (2019) discovered that using infographics in context-based learning to improve students' scientific literacy was effective. Punzalan and Quiambao (2019) conducted the same study and used the same indicators as in PISA 2015: scientifically analyze phenomena, evaluate and design scientific investigations, and scientifically interpret and evaluate findings. The study found that using the created infographics improved student learning and can be utilized as instructional materials and teaching aids when introducing science concepts to students. Because it is a visual, electronic type of information that 21st century learners can relate to, it can also be used to increase science literacy in various schools.

Hamadi (2019) added that the use of infographics enables students to display critical thinking abilities by filtering information, drawing connections, analyzing patterns, and generalizing based on the information provided. Yarbrough (2019) supported this finding, stating that the power of visual learning is becoming evident, and visual learning environments are becoming more prominent as teachers try to manage the information overload enabled by technological improvements. Additionally, Wise and Cooper (2019) proved that visual materials can assist people of all ages organize, clarify, and simplify difficult information and build comprehension by looking at how concepts relate to one another.

2.2 Theoretical framework

The theoretical grounds for learning using infographics have been built within the frameworks of the following theories: Cognitive Load Theory, defines learning as the process of forming and processing cognitive schemas about content to be learned and storing them in long-term memory. A considerable quantity of empirical data has demonstrated the restricted boundaries of human working memory, and cognitive load theory says that instructional design must respect these constraints (Leppink, 2017; Ocampo & Del Rosario, 2022).

Mayers Cognitive Theory of Multimedia Learning provides a valid model for multimedia learning. According to this, the human cognitive system is divided into long-term memory and working memory, with the working memory being the core of the model. It is strongly limited in capacity and represents the limiting factor in the learning process. An overload of the working memory results in cognitive overload, which results in an immediate termination of the learning process. Consequently, all design principles to be derived from the Cognitive Theory of Multimedia Learning aim at reducing the cognitive load in the working memory (Makransky & Petersen, 2021).

The Dual Coding Theory (DCT), which proposes by Allan Paivio assumes that there are two distinct cognitive subsystems. One is focused on language, whereas the other is concerned with the representation and processing of nonverbal objects (imagery). It is a broad cognitive framework that encompasses both verbal and nonverbal cognition. Nonverbal imagery is concerned with nonlinguistic perceptions of reality. Because its primary purpose is the creation of mental images, it is commonly referred to as imaging. The verbal code is concerned with language. This provides the methods for message communication, encoding, and decoding. (Yui, et.al 2017).

3. Methodology

3.1 Research design

Descriptive developmental research design was utilized in the study to gather the needed data to answer the research problems. It is descriptive in nature because a survey method was employed to determine the students' dual coding cognition, level of preference between static and animated infographics and the ratings of the expert evaluators on the developed infographic learning materials. On the other hand, the developmental research design was used to develop,

design, and evaluate infographic learning materials in accordance with the criteria or standards set to be considered effective.

3.2 Respondents of the study

The samples were chosen using a simple random technique. The respondents were 160 grade 8 students from Alaminos Laguna in the Philippines who were enrolled in the modular distance learning modality. They were chosen because the researcher prepares and distributes their instructional materials and keeps track of and assesses their learning and achievement.

3.3 Research instruments

The study used a self-made questionnaire with inputs from the review of related literature and studies. A Likert scale was utilized to assess the respondents' judgments, opinions, and frequency with which a specific task or activity is performed. There were three questionnaires developed: Dual Coding Questionnaire, Students' Level of Preference Questionnaire and Expert Evaluators Questionnaire on the Devised Infographics.

The development of infographics began by referring to the Department of Education's most essential learning competencies for the third quarter. These served as the basis for choosing the topics (States of Matter, Phase Changes, Atom's Subatomic Particles and Periodic Table of Elements) that were included in the development of infographic materials. Dual coding cognition was considered on how to best represent the information through visuals and on how to properly organize the concepts and ideas to prevent information overload. Canva free web application was used to create the static infographics. After doing the static infographics, the researcher proceeded with drafting the animated infographics. The static infographics served as the template in doing the animated infographics. To add animation on images and text, create smooth transition and basic sounds, the researcher utilized the Power Point Presentation and saved it in mp4 format.

3.4 Research procedures

The researcher seeks first the validation of the expert evaluators for the comments and suggestions regarding the research instruments. After revising the instruments, the researcher proceeded with the pilot testing involving 30 students from other section. The results of the pilot testing were sent to the researcher's statistician for reliability test. After passing the reliability

test, the researcher asks for the final approval of her subject specialist and adviser. Then she sent a letter requesting the Public Schools Division Superintendent-Division of Laguna, Schools District Supervisor-District of Alaminos and to the school principal to ask for their permission to conduct this study. After securing their approvals, she proceeded to the administration of the validated research instruments.

The dual coding questionnaire and pretest were given in printed format on the first week of the 3rd quarter on the students scheduled date and time of distribution of modules. They were given one week to answer the questionnaires. On the following week, the researcher retrieved the dual coding questionnaire and pretest. This is also the start of the administration of infographic learning materials. The static infographic was distributed in printed form, whereas the animated infographic was uploaded in YouTube and its link was distributed in the students' group chat on the same day of the distribution of static infographics. The teacher kept track as to how many students watched the animated infographics by asking them to respond with a thumb's up emoji on the link if they were finished watching the video. This was the weekly routine for distributing self-learning modules and retrieving completed learning materials from students. The lesson was completed on the seventh week of the third quarter, and on the last week, the posttest was given to assess the students' understanding of the lessons. After the administration of the research instruments, all the data gathered were prepared for statistical analysis. To protect the respondents' identity and confidentiality, the names and other personal information of the respondents were withheld during the data collection, analysis, and reporting of the study results.

3.5 Statistical treatment of data

The study utilized the mean and standard deviation to analyze and interpret the results of the dual coding cognition assessment, the students' level of preference between static and animated infographic and the expert evaluators' scores on the effectiveness of the devised infographics. Frequency-Percentage Distribution formulae enable the researcher to identify the most frequent scores and identify the students' level of understanding in the pretest and posttest in each scientific knowledge components. Moreover, T-test formula was utilized to compare whether the results of the pretest and posttest scores of the students in terms of the four components of scientific knowledge are statistically different from each other.

4. Findings and Discussions

Table 1

Dual Coding Cognition Assessment

Verbal Coding							
Decoding Skills	**M**	**SD**	**VI**	**Encoding Skills**	**M**	**SD**	**VI**
I read unfamiliar words correctly.	4.26	0.66	P	I spell unfamiliar words correctly.	3.27	0.86	MP
I recall details of what I have read or watched.	4.09	0.74	P	I provide a list of key concepts or ideas from what I have read.	3.72	0.84	P
I explain accurately how graphics is related to the text.	3.82	0.73	P	I write a clear explanation how graphics are related to the text.	3.62	0.80	P
I understand what I have read or watched.	3.78	0.72	P	I provide a summary of what I have read using own words.	3.28	0.86	MP
I make accurate connections between ideas and concepts.	3.59	0.72	P	I create outline to see how concepts are related.	3.53	0.84	P
Overall Mean	3.91	0.57	P	Overall Mean	3.48	0.67	P
Imagery							
Mental Imagery	**M**	**SD**	**VI**	**Realistic**	**M**	**SD**	**VI**
I form a clear and detailed mental image of an object or scene that I read.	4.36	0.65	P	I watch video tutorials to understand difficult lessons.	4.36	0.65	P
I make mental images that resembles the real object.	4.21	0.73	P	I read books with pictures to help me comprehend the lesson.	4.21	0.73	P
I associate mental images to the things or concepts that I need to remember.	4.42	0.60	P	I pay close attention to pictures to remember the concepts easily.	4.42	0.60	P
I visualize how things should be done before actually doing it.	3.78	0.68	P	I recall the concepts easily when they are represented with pictures.	3.78	0.68	P
I create a schematic representation of things or events in my mind.	3.60	0.69	P	I look for diagrams and illustrations to realize connections between concepts and ideas.	3.60	0.69	P
Overall Mean	4.07	0.50	P	Overall Mean	4.07	0.50	P

Legend: 1.00-1.49 (Not at all); 1.50-2.49 (Rarely Practiced): 2.50-3.49 (Moderately Practiced); 3.50-4.49 (Practiced); 4.50-5.00 (Highly Practiced)

The table shows that the result of the students' decoding skills can be interpreted as "practiced." This implies that the students can regularly carry out decoding skills that range from reading words correctly, recall the details of what they have read, explain the relationship

between graphics and texts, understand what they have read and make connections between concepts and ideas. The results are consistent with Rufon (2021), which she found out that junior high school students are competent in terms of applying decoding skills such as recognizing words clearly and effectively, pronouncing words correctly, and reading words with proper pronunciation, diction, and intonation. Quick word recognition provides easy access to the meaning of the concepts they have read. This also aids in understanding and comprehending written texts which is necessary for basic knowledge awareness and understanding. According to the same author, the use of graphic organizers across the curriculum and the application of concept imagery skills continues the development of students' decoding skills.

In terms of encoding skills, the results suggest that students can regularly perform different encoding skills such as spell the word correctly, write a concise and accurate explanation, outline and provide a summary of concepts learned. This also means that students know how to put thoughts, ideas or information into symbolic forms such as words, pictures and the likes to deliver messages effectively. Velentzas and Broni (2014) explain that encoding involves the process of translating information into a message in the form of symbols that represent ideas or concepts. This process translates ideas or concepts into the coded message that the receiver can understand. Encoding skills are honed and practiced as a person tries to communicate his thoughts and ideas. Akilandeswari et al. (2015) further add that encoding skills are further enhanced by taking an idea or mental image, associating that image with words, and then speaking those words to convey a message.

The result of the dual coding cognition in terms of mental imagery reveals that students always form mental representations from perceived or remembered objects, represent a mental picture of reality, and create mental models that can aid in their cognitive processes. Klein and Crandall (2018) support this claim and state that mental imagery is a powerful concept that is widely used. According to Feldman and Greeson (2022), creating a mental image of a word can support visual reading process and writing instruction. Imagery processing has been found to be a part of the human general cognitive functioning. Mental imagery facilitates learning and memory performance in both children and adults.

On the other hand, the result of the dual coding cognition in terms of realistic implies that the students’ abilities to perceive reality or visual stimuli from the surroundings are being

practiced and applied to their learning process. These visual stimuli include videos, books, pictures, illustrations, and diagrams. Wise and Cooper (2019) state that visual materials are helpful tools for all ages to organize, clarify, simplify complex information and construct understanding through exploration of relationships between concepts. This result was backed up by Yarbrough and Coulter (2019), which states that the power of visual learning becomes apparent, and visual learning opportunities are increasing in prevalence as teachers try to manage the information overload available through improved technology (Coulter, 2015).

Table 2

Students Level of Preference for Static and Animated Infographics

Indicators	Static Infographics			Animated Infographics		
	Mean	SD	VI	Mean	SD	VI
1. improve my critical thinking	4.37	0.71	P	4.51	0.60	HP
2. improve my motivation to learn	4.26	0.72	P	4.38	0.69	P
3. make it easier for me to recall information	4.24	0.71	P	4.37	0.61	P
4. capture my attention and keep me engaged	4.26	0.69	P	4.32	0.71	P
5. help me to understand hidden relationships	4.18	0.73	P	4.31	0.65	P
6. help me to communicate what I have learned	4.31	0.69	P	4.31	0.77	P
7. help me easily understand complex information	4.31	0.68	P	4.36	0.69	P
8. help me organize information into logical groups	4.30	0.61	P	4.14	0.83	P
9. help me to easily connect new and old information	4.19	0.73	P	4.18	0.78	P
10. enable me to determine key words and concepts in text	4.16	0.74	P	4.30	0.7	P
Overall	**4.26**	**0.45**	**P**	**4.32**	**0.5**	**P**

Legend: 1.00-1.49 Highly Unpreferred, 1.50-2.49 Unpreferred, 2.50-3.49 Moderately Preferred, 3.50-4.49 Preferred, 4.50-5.00 Highly Preferred, M= Mean; SD= Standard Deviation

The result on table 2 conveys that the students perceived the use of static infographics as an important tool in improving critical thinking, motivation, recall, engagement and conceptual understanding. This was attested by the study of Ismaeel and Mulhim (2021) where static infographics prove its effectiveness in terms of providing an easier way to understand complex subjects. The result of their study asserts that static infographics allow students to visually navigate all the components at the same time which enables students to discover relationships between these components much easier and leads to improving learning conceptual processes. This may decrease cognitive load leading to simpler cognitive tasks and information processing. Therefore, the information can be retained longer in visual memory.

The data also show that animated infographics were seen by the students as an important tool in their learning process due to its ability to capture attention, improve motivation, strengthen the retention, and recall of information and present complex information in an easier manner. Dunlap and Lowenthal (2016) state that by adding subtle micro-animations such as interactive elements, pops of color, or smooth transitions help highlight information and make the infographic become more than just an informative piece of content. It also entertains the audience which in turn builds an emotional connection with them. Motion in the infographic makes the story come to life, captures emotion, and evokes curiosity. It elevates the infographic from good to great. As a result, animated infographics help in enhancing students' ability to organize information in a logical way and provide a new way of decongesting information (Fadzil, 2018).

Table 3

Expert Evaluators Ratings on the Devised Infographics

Indicators	Static Infographics			Animated Infographics		
	Mean	**SD**	**VI**	**Mean**	**SD**	**VI**
1. Design	4.68	0.38	VG	4.61	0.34	E
2. Content	4.78	0.36	E	4.78	0.36	E
3. Clarity	4.75	0.46	E	4.69	0.46	E
4. Representation	4.75	0.36	E	4.75	0.36	E

Legend: 1.00-1.49 (Poor); 1.50-2.49 (Fair): 2.50-3.49; (Good); 3.50-4.49 (Very Good); 4.50-5.00 (Excellent)

The table presents the ratings given by the expert evaluators in the created static and animated infographics. In terms of design, static infographic got a verbal interpretation of "excellent". From the result, it can be inferred that the overall design of static infographics has met the necessary requirements to be classified as excellent. These include the use of colors that added aesthetic value and compliments with the overall design of the infographics, strong use of visual elements such as images, pictures and illustrations that emphasizes the concepts presented. Naparin and Saad (2017) defines an excellent infographic as consisting of a good title, suitable graphs, charts, pictures, images, readable text, font and have an excellent use of color and an appropriate design format. On the other hand, animated infographics obtained a verbal interpretation of "very good". This implies that the overall design of the animated infographics was perceived by the evaluators as commendable and that the fonts, colors, layout, imagery,

motions, and animations complement each other and provide a great way of visualizing the information it contained.

In terms of content, both types of infographics gained a verbal interpretation of “excellent”. The scores given by the evaluator showed that the generated infographics are thought to be of high quality in terms of logically organized contents, suitability of the terminology and vocabularies employed, and simplicity of the contents. By presenting concepts in a way that ranges from simple to complex, logical organization of the content is demonstrated. Links between concepts and ideas are also made clear so that the reader will easily find patterns and connections between concepts presented. Furthermore, the terminologies and vocabularies used were chosen to be within the students' comprehension level and will be easily decoded.

Likewise, the table also indicates that the criteria set in ensuring the clarity of the developed infographics were all achieved and exhibited in an exceptional way. This also mean that the infographics present the concepts and information in a straightforward, succinct, and clear manner, without the use of graphics or other visual elements that can impede the flow of information or cause misunderstanding.

Additionally, the result of both static and animated infographics in terms of representation implies that design elements, visuals and illustrations used best fit for their purpose of representing information for better comprehension. It also suggests that the criteria to be considered excellent in terms of representations given were all met.

Table 4 shows the frequency distribution of the pretest and posttest scores of the grade 8 students. In terms of recognizing scientific terms and concepts it can be gleaned from the table that students were able to quickly recognize scientific terms and concepts after the utilization of infographics. This also mean that their scientific vocabulary improved. This is attributed to infographics' ability to draw attention to important details and information and present it in a more engaging manner. The study of Ortiz and Aliazas (2021) validated this findings and state that infographics present difficult data or concepts into straightforward, easy, and aesthetically beautiful styles which in turn encourage active participation in the data-collection process that improve retention and recall.

Table 4

Students Pre-test and Posttest Scores on Scientific Knowledge

Score	Recognize Scientific Terms and Concepts				
	Pre-test		Posttest		VI
	F	%	F	%	
90 and above	-	-	144	90	Outstanding
85-89	-	-	16	10	Very Satisfactory
80-84	10	6.25	-	-	Satisfactory
75-79	122	76.25	-	-	Fairly satisfactory
74 and below	28	17.5	-	-	Unsatisfactory
Total	**160**	**100**	**160**	**100**	
	Describe Scientific Terms and Concepts				
Score	**Pre-test**			**Posttest**	**VI**
	F	**%**	**F**	**%**	
90 and above	-	-	124	77.5	Outstanding
85-89	-	-	36	22.5	Very Satisfactory
80-84	8	5	-	-	Satisfactory
75-79	100	62.5	-	-	Fairly satisfactory
74 and below	52	32.5	-	-	Unsatisfactory
Total	**160**	**100**	**160**	**100**	
Score	**Relate Scientific Terms and Concepts**				
	Pre-test		**Posttest**		**VI**
	F	**%**	**F**	**%**	
90 and above	-	-	62	38.8	Outstanding
85-89	-	-	85	53.1	Very Satisfactory
80-84	-	-	13	8.1	Satisfactory
75-79	57	35.6	-	-	Fairly satisfactory
74 and below	103	64.4	-	-	Unsatisfactory
Total	**160**	**100**	**160**	**100**	
	Explain Phenomena Scientifically				
Score	**Pre-test**		**Posttest**		**VI**
	F	**%**	**F**	**%**	
90 and above	-	-	47	29.4	Outstanding
85-89	-	-	98	61.3	Very Satisfactory
80-84	-	-	15	9.4	Satisfactory
75-79	38	23.7	-	-	Fairly satisfactory
74 and below	122	76.3	-	-	Unsatisfactory
Total	**160**	**100**	**160**	**100**	

In terms of students' ability to describe scientific terms and concepts, it can be seen from the table that after the use of infographic learning tools, the students achieved an outstanding performance in their posttest, which means they can accurately describe concepts and ideas. This is due to the infographics' ability to combine meaningful visuals to text that enable the students to process them efficiently. According to Oranç and Küntay (2019), research has shown that when facts are combined with interesting images, people are much more likely to understand and remember the materials. Also, a good visual will motivate learners and improve comprehension.

Furthermore, it can be observed that students' ability to discover patterns and create meaningful connections between concepts and ideas presented are enhanced. This is due to the fact that infographics make it simple to present massive amounts of complex data, effectively deliver a message by associating pictures to highlight ideas and concepts and allow students to draw connections and see patterns in the data to make their learning more effective. Wise and Cooper (2019) findings state that infographics are helpful tools for all ages to organize, clarify, simplify complex information and construct understanding through exploration of relationships between concepts.

The result also suggests that there is a considerable improvement in students' ability to apply concepts learned to explain and predict observations of the natural world. Knowing how to apply this understanding efficiently in scientific investigations and in practical reasoning could make abstract ideas more accessible and relevant to students' learning. According to Hamadi (2019), the use of infographics helps the students to demonstrate critical thinking skills by filtering information, establishing relationships, identifying patterns, and generalizing ideas based on the facts presented.

Table 7

Pre-test and Post-test Scores of Students

Scientific knowledge	Pre-test		Posttest		T	df	Sig. (2-tailed)
	M	SD	M	SD			
Recognize scientific terms and concepts	4.39	1.69	15.09	1.09	81.74	159	.000
Describe scientific terms and concepts	4.35	1.67	14.44	1.31	-81.81	159	.000
Relate scientific terms and concepts	3.14	1.42	12.84	1.57	-82.75	159	.000
Explain phenomena scientifically	2.59	1.31	12.52	1.63	-79.777	159	.000
Overall	12.52	5.02	54.88	4.13	-154.78	159	.000

Legend: $p > .05$ (not significant); $p \leq .05$ (Significant)

Table 7 shows that there is a significant difference between the pre-test and posttest performance of the students in scientific knowledge in terms of recognizing, describing, and relating scientific terms and concepts and explaining phenomena scientifically. This significant difference implies that the use of infographics is effective in enhancing scientific knowledge. This outcome can be attributed to infographics' capabilities in providing detailed information with visual representation which in turn improves the students' ability to learn and increase memory retention. Additionally, these visual cues motivate students to learn and acquire

knowledge, organize thoughts, and discover meaning and relationships and apply this knowledge to explain scientific phenomena.

The findings of Damyanov and Tsankov (2018) demonstrate the importance and effectiveness of infographics in the teaching and learning process. By using images to strengthen the pupils' visual system's capacity to recognize patterns and trends, it enhances cognitive ability. Compared to written or spoken text, pictures and visuals help students learn and recall information more quickly and effectively. This benefit is increased when text and visuals are mixed, and students are given greater opportunities for interaction and involvement.

This also agrees with the dual coding theory that stated that presenting information through multimedia facilitates knowledge construction in a learner's mind by making connections between the various forms of information (verbal and non-verbal). Presenting information this way helps transfer knowledge to the learner's memory in multiple forms, which then can be retrieved easily and in more than one way (Ismaeel & Mulhim, 2021).

5. Conclusion

Infographics allows the teacher to offer an innovative, attractive and convenient way of delivering lesson. Based on the results of the study, the following conclusions were drawn: infographics were useful in terms of improving academic performance in science among learners; infographics are effective in enhancing the student's scientific knowledge in terms or recognizing, describing and relation scientific terms and concepts and explain phenomena scientifically; both animated and static infographics were preferred and regarded by the students as an important instructional tool. In addition, there is a significant difference between the mean pre-test and posttest scores of students who are exposed to the use of infographics on all its components, thus the null hypothesis was not sustained. Future researchers may explore the effectiveness of using infographics to different grade levels and other subject areas. They may consider studying the effects of different types of infographics in students' level of achievement.

References

Akilandeswari, V., Kumar, A. D., Freeda, A. P., & Kumar, S. N. (2015). Elements of effective communication. *New Media and Mass Communication*, *37*, 44-47.

Damyanov, I., & Tsankov, N. (2018). The role of infographics for the development of skills for cognitive modeling in education. *International Journal of Emerging Technologies in Learning (iJET)*, 13(1), 82-92.

Dunlap, J. C., & Lowenthal, P. R. (2016). Getting graphic about infographics: design lessons learned from popular infographics. *Journal of Visual Literacy*, *35*(1), 42-59.

Eilks, I., & Hofstein, A. (2017). *Curriculum development in science education*. In K. S. Taber & B. Akpan (Eds.), Science education: New directions in mathematics and science education (pp. 167–181). Sense Publishers. https://doi.org/10.1007/978-94-6300-749-8_13

Fadzil, H. M. (2018). Designing infographics for the educational technology course: perspectives of pre-service science teachers. *Journal of Baltic Science Education*, *17*(1), 8.

Feldman, G., Westine, M., Edelman, A., Higgs, M., Renna, M., & Greeson, J. (2022). *Cognitive and Affective Mindfulness Scale-Revised (CAMS-R).* In Handbook of Assessment in Mindfulness Research (pp. 1-24). Cham: Springer International Publishing.

Guarnera, M., Pellerone, M., Commodari, E., Valenti, G. D., & Buccheri, S. L. (2019). Mental images and school learning: A longitudinal study on children. *Frontiers in Psychology*, *10*, 2034.

Hamadi, H., Kates, F. R., Audi, G. R., Larson, S. A., & Kates, M. M. (2019). Enhancing and Impacting the Online Classroom Environment with Infographics. *eLearn*, *2019*(4).

Ismaeel, D., & Al Mulhim, E. (2021). The influence of interactive and static infographics on the academic achievement of reflective and impulsive students. Australasian Journal of Educational Technology, 37(1), 147-162.Leppink, J. (2017). Cognitive load theory: Practical implications and an important challenge. *Journal of Taibah University Medical Sciences*, *12*(5), 385-391.

Klein, G., & Crandall, B. W. (2018). The role of mental simulation in problem solving and decision making. In *Local applications of the ecological approach to human-machine systems* (pp. 324-358). CRC Press.

Lyra, K. T., Isotani, S., Reis, R. C., Marques, L. B., Pedro, L. Z., Jaques, P. A., & Bitencourt, I. I. (2016, July). Infographics or graphics+ text: Which material is best for robust learning. In 2016 ieee 16th international conference on advanced learning technologies (icalt) (pp. 366-370). IEEE.

Makransky, G., & Petersen, G. B. (2021). The cognitive affective model of immersive learning (CAMIL): A theoretical research-based model of learning in immersive virtual reality. *Educational Psychology Review*, *33*(3), 937-958.

Magsambol, B. (2020, December 9). Ph lowest among 58 countries in math, science – global assessment. Rappler-Philippines. Retrieved January 8, 2021, from https://www.rappler.com/nation/filipino-students-lagging-behind-math-science-timms-international-results-2019/

Naparin, H., & Saad, A. (2017). Infographics in Education : Review on Infographics Design. *The International Journal of Multimedia & Its Applications, 9*, 15-24.

Ocampo, M. R., & Del Rosario, A. L. (2022). Translation-Based Instructional Material in Mathematics and Problem-Solving Abilities of Grade 5 Pupils. *International Journal of Scientific and Management Research*, *5*(3), 225-241.

Oranç, C., & Küntay, A. C. (2019). Learning from the real and the virtual worlds: Educational use of augmented reality in early childhood. *International Journal of Child-Computer Interaction*, *21*, 104-111.

Ortiz, A. M., & Aliazas, J. V. (2021). Multimodal Representations Strategies in Teaching Science Towards Enhancing Scientific Inquiry Skills Among Grade 4. *IOER International Multidisciplinary Research Journal*, *3*(3), 107-118.

Parkinson, M. (2016). Infographic tips and tools. Talent Development, 70 (5),p. 26-28. Retrievedfromhttps://billiondollargraphics.com/wpcontent/uploads/2016/05/MikeParkinson_Infog raphics_TD.pdf

Quiambao, C., & Punzalan, J. (2019). Development and validation of infographics based on the least mastered competencies in Physics. *International Journal of Recent Technology and Engineering, (IJRTE)*, *8*(1), 352-357.

Rufon, J. I. (2021). Decoding, Vocabulary And Comprehension Skills Of Junior High School Students. *ResearchJet Journal of Analysis and Inventions*, *2*(06), 1-11.

Sacopla, Ma. And Yangco, R. (2016). Infographics: Effects on student coding skills and conceptual understanding in Biology. *The Asian Conference on Education 2016, Official Conference Proceedings. The International Academic Forum (iafor), www.iafor.org*

Sriphrom, P., & Onthanee, A. (2021). Development of learning activities by using context-based learning with infographics to enhance scientific literacy and attitude toward science on

the topic of chemical bonds for grade 10 students. *Journal of education naresuan university*, 23(3), 159-174.

Velentzas, J. O. H. N., & Broni, G. (2014). Communication cycle: Definition, process, models and examples. *Recent advances in financial planning and product development*, *17*, 117-131.

Wise, M., Cooper, C. (2019) Increasing the Value of Graphic Organizers. Edutopia: https://www.edutopia.org/article/increasing-value-graphic-organizers

Yarbrough, J. R. (2019). Infographics: in support of online visual learning. *Academy of Educational Leadership Journal*, *23*(2), 1-15.

Yui, L., Ng, R., & Perera-WA, H. (2017). *Concrete vs abstract words–what do you recall better? A study on dual coding theory* (No. e2719v1). PeerJ Preprints.

Zainuri, A., & Huda, M. (2022). Understanding Scientific Literacy and Pedagogy Competence: A Critical Insight into Religious Integration Thinking Skills. *Journal of Educational and Social Research*, *12*(1), 273-273.