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# Digital Infographics Design (Static vs Dynamic): Its Effects on Developing Thinking and Cognitive Load Reduction

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**Abstract.** The current study investigates the effect of the difference between two styles of infographics (static vs. dynamic) on developing visual thinking and reducing the cognitive load of grade six students in their science course. The researcher relied on the quasi-experimental design. The random sample population included 40 students who were divided into two equal experimental groups: the first group of students was exposed to static infographics, while the second was exposed to dynamic infographics. The experimental treatment of independent variables was done by Wepik and Vyond web applications. Data were collected by two tools, a Visual Thinking Test (prepared by the researcher) and a Cognitive Load Scale (NASA-TLX). The results indicated that there was a significant impact of dynamic infographics on developing students' visual thinking and reducing their cognitive load compared with static infographics. This can be attributed to the diverse stimuli and multimedia elements that dynamic infographics provide, which are compatible with the students' tendencies and abilities, as well as their learning, cognitive and perception styles. Furthermore, the presentation of concepts in a sequential and orderly manner can allow for in-depth understanding and assimilation with a limited cognitive load.

**Keywords:** static infographics; dynamic infographics; visual thinking; cognitive load

## 1. Introduction

Providing interactive e-educational content is an issue that is constantly raised in education communities around the world. The repercussions of the COVID-19 pandemic on education have driven many researchers to find a different style to provide interactive e-educational content through which students can form serious interaction towards benefiting from this content and also to developing many skills, the most important of which are thinking skills, and also benefiting from this content in reducing the cognitive load they face when learning from educational content that is traditionally presented. Several studies have suggested new patterns in providing interactive electronic educational content.

It is important to remember students now belong to the digital generation that has different characteristics, requirements, and needs, the most important of which is the need to interact with and participate in educational content delivered in a manner that allows them to do so throughout their learning period.

Between 2010 and 2012, the use of Infographic Technology began to increase strongly. From then until now, the massive Internet revolution has driven the increasing need for infographics. The term infographics is a portmanteau of two words: information, which refers to data, and graphics, which refers to images and drawings. Converting information into images and graphics helps to simplify complex pieces of information and facilitate their learning (Ali, 2019). In the search for the best instructional methods and styles, the use of infographics offers various advantages and merits. It was a fertile soil for researchers to study its impact on learners for different instructional materials, educational stages, and study levels, starting from kindergarten. In this regard, Al-Shuaibi (2018), for example, showed the effectiveness of infographics in developing visual memory for kindergarten children. As for other educational stages, Alzahrani (2020) demonstrated the importance of infographics in English vocabulary retention for grade eight students. Also, Shafi et al. (2018) showed the effectiveness of infographics at the preparatory stage. At the university level, Alsaadoun (2021) showed the efficiency of infographics in developing the concepts of instructional design for university students. Moreover, infographic technology has the advantage of being able to reach students of all groups, even the disabled, as discussed, for example, in Said (2019) which demonstrated the effectiveness of that technology in raising the achievement levels of students with hearing disabilities. Thus, infographics have taken a primary role through raising the achievement levels and increasing learning retention of students in different stages, in addition to developing various visual thinking aspects and skills, which depend on understanding displayed images and eliciting concepts and information from them; Habeeb (2020) and Mohamed's (2021) showed positive results from the use of infographics in the development of learners' visual thinking. Both studies involved subjects relating to social sciences; whereas the current study seeks to employ infographics for applied science subjects. Thus, the infographics used will be different in their content and presentation style from those used in humanities and social science, therefore there is a need to indicate the extent to which infographics affect thinking and reduce the cognitive load of science students.

The strength and effectiveness of infographics vary according to the type and patterns used. For example, Mustafa (2021) showed that there are varying ratios and degrees between the two types (static vs. dynamic) of infographics, concluding that the effectiveness of static infographics for instantaneous comprehension came to 80%, while dynamic infographics were 55% more useful for retrieving information, which indicates the broad capabilities of infographics of reducing the cognitive load of learners.

Guzmán et al. (2021) pointed out that the acquisition of experimental equipment has become a problem due to its high costs. To partially solve this problem, the scientific community has developed new low-cost technologies that don't require users to have extensive knowledge of electronics and programming.

In light of this, and based on the many studies that have indicated the importance of this technology in raising learners' motivation and increasing their achievement and willingness to learn, the researcher proposed the use of infographics in presenting scientific concepts to sixth grade students, especially because it contributes to self-learning. Keeping in mind the existence of at least three types of infographics, the present study aims to discuss the differences between static and dynamic types, and, furthermore, to investigate the patterns that are the most appropriate for students' learning, and the most effective in their retention of scientific concepts. Through my work with supervising field training in schools, I noticed that providing educational content to students in the traditional way does not help students develop their critical thinking skills, despite the students' motivation to share their ideas in the lessons. Additionally, teachers at these schools confirmed that the traditional presentation of learning materials bears a substantial cognitive load for many students. Thus, the main research question can be stated as follows: What is the effect of the difference in the two main types of infographics (static vs. dynamic) in the presentation of instructional content among grade six students in a science course? The main objective of the research is to measure the difference between the aforementioned styles (static vs. dynamic) when presenting instructional content and its effects on visual thinking and cognitive load among grade six students.

## 2. Research Theoretical Background

### 2.1 Infographics

As one of the tools used in conveying messages to the target groups across many fields, infographics are highly efficient since they can give a comprehensive explanation of the concepts that range from the least to the most complex (Kelidou & Siountri, 2020). With the spread of infographics and the diverse methods and ways in which they are used, many definitions have been assigned to them; for example, Al-Shaltoot (2016) defined infographics as "the art of transforming data, information and complex concepts into images and graphics that can be acquired, understood and assimilated clearly and interestingly. This technique is characterized by presenting complex and difficult information in a smooth, easy and clear way" (p. 111). Meanwhile, Mustafa (2021) defined infographics as a "visual and reduced narration of complex information and data through drawings, icons and illustrations with the aim of enhancing the understanding of the recipient and communicating the meaning in an interesting and attractive way." Based on these, infographics can be defined as a creative, innovative instructional means through which both simple and complex scientific concepts can be conveyed in the form of drawings, images graphs, charts and attractive texts that enable students to easily understand these concepts, regardless of their educational levels. The types of infographics vary according to the method of classification, as many studies classify these according to the presentation type, use, method of presentation, and the quality of the information provided (e.g. Al-Sadhan, 2020; Muhammad et al., 2019; Saeed, 2019). However, the main research interest here classifies infographics based on the method or style of presentation, which is divided into two types: static and dynamic infographics, allowing for the study of the impact of these two patterns on developing visual thinking skills and reducing the perceptive/cognitive load of learners.

*2.1.1 Static infographics*

Static infographics are considered one of the most used infographic patterns, due to the ease of creating them. Many websites provide ready-made templates to help produce this pattern, such as Wepik, freepik, Piktochart and others, in addition to some computer programs, such as PowerPoint. Aldalalah (2021) defined this as "a static design and a diagram or chart in the form of pictures, images, drawings and graphics with information about a specific topic that continuously clarifies the idea and explains it". In the same context, Abdel and Heba (2019) adds that this pattern or style displays the contents steadily, which makes it easy to display, publish and share feasibly. Consequently, for the purposes of this study, the static infographics are defined as a fixed design for a specific topic that contains graphical forms, drawings, pictures, charts, and information about that target topic, so as to display data in a simplified, clear, and easy way that is attractive to learners.

As shown by Alsaadoun (2021), static infographics can be extremely effective for developing the concepts of information technology among university students. Similarly, AlRajhi (2020) confirmed the role of static infographics in enhancing students' learning and retention of different terms, and increasing their motivation to learn because of the factors and features provided that attract their attention. Also, Muhammad et al. (2019) showed the effectiveness of static infographics in developing visual thinking among preparatory school students.

*2.1.2 Dynamic infographics*

With the current technological trends and developments, along with people's attraction to images and animation, animated/dynamic infographics have come to the fore and have become more popular. Thus, many programs and websites can facilitate the design and production of this pattern, including websites like as Vyond and Powtoon. Ali (2019) defined animated/dynamic infographics as "the animated or moving data/information design that includes the sound element, which take the form of music, sound deepening, or sound effects to attract the learner's attention". Wickens (2021) referred to one of the models of attention theory, which is supervisory control, indicates that, in many attention-relevant environments, the human operator is confronted with a wide array of dynamic sources of information. These are referred to as Areas of Interest. These are the areas a human user is attracted towards and interacts with on purpose, which explains students' interest in any source of information that is characterized by movement and interaction. Furthermore, this explains the added value of the dynamic infographic for student learning. Thus, for the purposes of this study, dynamic infographics can be defined as an animated design that combines between concepts and knowledge represented by images, tables and graphics, and appropriate live sounds and movement that give life to the design. This allows for displaying a certain concept divided into purposeful, attractive visual forms.

As with static infographics, dynamic infographics have been proven extremely effective in the educational process, and its ability to present information and communicate it to learners in an easy and smooth way. In this regard, Abdul Hamid et al. (2020) proved the effectiveness of dynamic infographics in developing chemical concepts among secondary school students and their acquisition of practical skills in that school subject. The researchers recommended the using dynamic infographics for presenting concepts that are difficult for students to comprehend. Also, Hamid et al. (2020) confirmed the effective role of this pattern in simplifying the Arabic grammar for university students, who urgently and greatly demanded the design of complex courses and syllabi through this style, because of its vital role in facilitating comprehension of the curriculum and increasing their focus. Finally, Lievemaa (2017) showed the positive impact of including and integrating this pattern in digital textbooks in Finland.

A simple comparison between the two styles of infographics is presented in the following table:

**Table 1: comparison between the two styles of infographics**

| Static Infographics | Dynamic Infographics |
|---|---|
| Can only carry small amount of information. | Can carry relatively large amount of information. |
| Suitable for simplified design and content. | More complicated designs & organization are applicable. |
| Displayed as 2-dimensional data. | Animated and interactive information. |
| Can be embedded in almost every website, blogs, or social media with ease. | Can be embedded in certain websites. Some infographics are embeddable but will be shown as a static image of its first frame. |
| Since the infographic is in form of an image, the link can be easily copy-pasted. | The easiest way to spread interactive infographic is by copying and sharing direct link to the interactive infographic. |
| It is downloadable, printable and can be stored in other media. | Is not downloadable. Its shareability is limited. |
| It is better off with simple data with small potential of it being extended. | It is very suitable for ever-changing data, user-driven data content and multi-layered data. |

**2.2 Visual thinking**

You rarely find a teacher explaining an idea or anything who does not draw it on the board, putting signs and signals to communicate their idea to students. This way, they invite the students to visual thinking; that is, in a way that nourishes their thinking with the images seen by students. In this regard, literature and many research studies have suggested different definitions of visual thinking. For example, Reed (2013) posited that thinking visually documents the many ways pictures, and visual images influence our thinking. Much of comprehending language depends on visual simulations of words or on spatial metaphors that provide a foundation for conceptual understanding. Amer and Al-Masry (2016) defined it as "an intuitive approach that facilitates learning, and the more complex the task or idea is, the more useful this approach becomes". The authors also pointed out that this way of thinking involves using the right hemisphere where creativity and emotion are dominant. The sequence of information received by the eyes is organized intuitively. Thus, for the purposes of this study, visual thinking can be defined as a learner's ability to extract different knowledge and concepts from images, drawings, and different visual forms and keep them in memory, with the possibility of retrieving them when needed. Visual thinking consists of several skills, which, according to Al-Rashidi (2021) and Amer and Al-Masry (2016), can be arranged into five basic skills:

- Visual reading: the ability to identify the displayed shape and its components;
- Shape analysis: the ability to see relationships in shape and links and identify these relationships;
- The skill of perceiving relationships: the ability to find relationships between the elements of a figure and linking them;
- The skill of interpreting information: the ability to interpret and clarify the relationships between the elements of a figure; and
- The skill of deriving or inferring meaning: the ability to access new concepts and knowledge through the image presented.

These skills can be considered as steps that a learner goes through in their awareness of the visual forms displayed to them, since reaching the last skill is considered the primary goal that visual thinking aspires to. Many studies have shown the role of infographics in developing visual thinking, including Shafee et al. (2018), that confirmed the positive impact of infographics on visual thinking and raising achievement levels of preparatory stage students. Similarly, Al-Rashidi (2021) found that infographics contributed to the development of visual thinking of Faculty of Education students. Furthermore, Muhammad et al. (2020) showed the impact of infographics on the development of visual culture and visual thinking among university students. Finally, Habeeb (2020) demonstrated the importance of infographics in developing visual thinking among female students in their acquisition of some social concepts.

### 2.3 Cognitive load

Cognitive Load Theory is one of the most influential theories in the design and production of instructional technology materials, as it aims to develop a specific mechanism for instructional design based on the premise that working memory has a limited ability to deal with information (Alsherman, 2019). In this regard, Garnett (2020) argued that the Cognitive Load Theory can enable teachers to identify the ways in which their students learn, as well as the ways in which the brain processes different information. If a teacher can identify these ways or techniques, their instruction will be valid, and hence the instructor becomes able to provide information in the appropriate way. A review of the existing literature indicates that many definitions of cognitive load have been developed; for example, Posey (2019) defined it as "the amount of mental effort needed to do a task" (p. 115), while Hassan (2018) defined it as "a set of mental activities carried out by learners with the aim of storing information in memory, and hence recalling it" (p.6). Based on these, for the purposes of this study, cognitive load will be defined as the mental effort exerted by a learner to identify scientific concepts and their ability to recall them when needed. Some studies have devised a number of strategies to reduce the cognitive load for learners. Elsharman (2019) and Posey (2019) presented a number of these strategies: (1) content fragmentation: i.e. the target content to be presented is divided into small parts so that the learner can absorb and memorize them separately; and (2) use of sounds, images, and shapes: i.e. concepts and knowledge written in long texts can be replaced by graphics, images, and shapes. Several studies have shown the significant impact of infographics in reducing the cognitive load and increasing academic achievement, including Nazeer (2019) that showed the role of infographics in reducing the cognitive load of learners in e-learning environments. Meanwhile, Aldalalah (2021) confirmed the effectiveness of infographics in reducing the cognitive load of university students and increasing their creative thinking, as well as design and achievement capacities. Khalifa (2018) agreed that the use of infographics can reduce students' cognitive load, H'mida (2020) pointed out the role that animated or dynamic shapes play in reducing the cognitive load of learners more than static pictures and shapes. This was confirmed by Wang, Fang and Gu (2020) that found images and animation represent the least cognitive burden for students, who had the ability to retain knowledge well.

## 3. Research Hypotheses

Based on the literature reviewed, along with my personal experience with instructional technology and the design and production of interactive multimedia, the following hypotheses are proposed.

1. There will be a statistically significant difference at the significance level of 0.05 between the mean scores of the students of the first experimental group (static infographics pattern) and the second experimental (dynamic infographics pattern) in the post-administration of the visual thinking test in favour of the students of the second experimental group (dynamic infographics pattern).
2. There will be a statistically significant difference at the significance level of 0.05 between the mean scores of the students of the first experimental group (static infographics pattern) and the second experimental (dynamic infographics pattern) in the post-administration of the Cognitive Load Scale in favour of students of the first experimental group (static infographics pattern).

## 4. Research Methodology and Procedures

### 4.1 Research Design

The quasi-experimental approach was chosen for the purposes of this study. It was deemed appropriate for testing and measuring the effect of the difference of the two independent variables (static infographics and dynamic infographics) on the two dependent variables (visual thinking and cognitive load) regarding teaching science concepts to sixth graders. Furthermore, this approach provides higher external validity than most true experiments, and higher internal validity than other non-experimental approaches because they allow better control for confounding variables than other types.

In the experimental design of the intervention, the post-test equally matched groups design was used, excluding the pre-testing of the sample in the experimental groups because the measurement process for the dependent variables (visual thinking and cognitive load) depends on the style of presentation of the instructional content delivered through the independent variables (static vs. dynamic infographics).

**Table 2: Experimental design of the study**

| Group | Pre-testing | Experimental Treatment | Post-testing |
|---|---|---|---|
| 1st Experimental Group | NONE | Static Infographics Pattern | ○ Visual Thinking Test |
| 2nd Experimental Group | | Dynamic Infographics Pattern | ○ Cognitive Load Scale |

### 4.2 Research Sample

The target population included sixth-grade students in the Sultanate of Oman, whose ages ranged from 11 to 12 years. Generally, the characteristics of this group include speedy mental development, and the growth of their imagination from illusion to realism, which tends towards innovation and creativity. In addition, at this age, students show early signs of critical thinking towards the end of that stage. The research sample consisted of 40 sixth-grade students from a private school, who were divided into two experimental groups, each of which included 20 students. This number was suitable to be used as a sample for the current study. In addition, the students' records were reviewed in order to ascertain their similar or close ages and follow up on the students' achievement records and discuss them with the relevant teachers. Then, the students who shared similar levels, and their names of the students were used to create a new list. This was then used to select the research sample through regular randomized sampling.

### 4.3 Research tools

For the specific purposes of the current study, two main research tools were used: a visual thinking test, and a cognitive load scale. These are explained further in the sections that follow.

*4.3.1 Visual Thinking Test (prepared by the researcher):*

After reviewing the relevant literature (e.g., Fernandez et al., 2020; Ware, 2021; Mollon, 2017; Mouhebati; 2019; Sabry, 2020; Bystryantseva et al., 2020), a visual thinking test was prepared, based on the objectives and instructional content already designed as follows:

Objectives and test design: The main objective of this test was to assess the effectiveness of infographics technology, with its static and dynamic patterns, in developing visual thinking in science for sixth-grade students. The test included 10 questions, at a rate of two marks for each question. MCQ questions were chosen, since results of this type are objective (i.e., they do not depend on the student's written answers), with no interference from the researcher, as is the case in essay questions.

To determine the validity and reliability of the test, it was administered to a psychometric sample that consisted of 20 sixth-grade students, who were not from the main research sample. The data obtained from the psychometric sample was

uploaded to SPSS - a statistical program, then the validity and reliability was assessed as follows:
Validity of the test: Structural validity was verified according to two methods: internal consistency and the two terminal groups.

**A- The internal consistency method:**
The validity value for each item on the test was measured by calculating the correlation coefficients between the degree of each item and the total score. The results of the statistical analysis were as follows:

**Table 3: Correlation coefficients between the degree of each item and the total score**

| Item | Correlation | Item | Correlation | Item | Correlation | Item | Correlation | Item | Correlation |
|---|---|---|---|---|---|---|---|---|---|
| 1 | .486** | **3** | .640** | **5** | .560** | **7** | .510** | **9** | .535** |
| 2 | .667** | **4** | .399** | **6** | .634** | **8** | .563** | **10** | .477** |

**Significant at the 0.01 level

It is clear from the above table that there is a correlation between each item and the total score of the test. These correlations range between 0.667 and 0.399, which are positive and statistically significant at the level of 0.01.

**B- Validity using the two terminal groups:**
The scores of the psychometric sample were arranged on a scale in descending order, and the highest 25% (highest category of 5) and lowest 25% (lowest category of 5) were chosen. Given that the two categories were of small samples, the Mann Whitney test for independent samples was used to show the significance of the differences between the two categories on the total score of the scale/test. Table 4 below presents the findings:

**Table 4: Average ranks, total ranks, and the value of Mann Whitney and its significance**

<table>
<tr><th rowspan="3">Visual Thinking Test</th><th>Categories</th><th>No</th><th>Average ranks</th><th>Total ranks</th><th>U</th><th>Z</th><th>(sig)</th><th>Significance level</th></tr>
<tr><td>Highest category</td><td>5</td><td>8</td><td>40</td><td rowspan="2">0.000</td><td rowspan="2">2.66</td><td rowspan="2">0.000</td><td rowspan="2">Significant at the level of 030.0</td></tr>
<tr><td>Lowest category</td><td>5</td><td>3</td><td>15</td></tr>
</table>

It is evident that there are statistically significant differences between the highest category and the lowest category, and these differences favor of the highest category. That is, the test is valid, and its items possess a good discriminatory ability among students.

Test reliability:
Reliability was calculated using Cronbach's alpha coefficient and the Spearman-Brown coefficient on the validity and reliability sample. Table 5 below shows the two reliability coefficients for the scale.

**Table 5: Reliability coefficients using the Alpha-Cronbach and Spearman-Brown methods**

| Total score of the test | Alpha-Cronbach's value | Spearman-Brown value |
|---|---|---|
| | **0.734** | **0.760** |

It is evident that the test has a high degree of reliability through the split-half method.

*4.3.2 Cognitive Load Scale (NASA-TLX)*

To ensure the scale of cognitive load was compatible with the characteristics of the target sample group, as well as the requirements of the research, the cognitive load scale (NASA-TLX) developed by the Ames Research Center at NASA in the US, was selected (Hart, 2006). NASA-TLX is considered a widely used six-dimensional self-assessment instrument that has been adopted in several research studies. After translation and adaptation, its validity was confirmed by using predictive validity through the internal consistency and discriminatory validity methods.

1-Predictive validity:

(1) Internal consistency method:

The scale was administered to the psychometric research sample, consisting of 20 sixth-grade students. The internal consistency was calculated using the Pearson correlation coefficient. The correlation of each item in the scale was compared with the total score of the scale to verify this method. Table 6 below shows the resulting correlation coefficients.

**Table 6: The correlation of each item of the scale with the total score of the scale**

| Item | Correlation | Item | Correlation | Item | Correlation |
|---|---|---|---|---|---|
| 1 | ****0.630** | **3** | ****0.424** | **5** | ****0.782** |
| 2 | ****0.826** | **4** | ****0.760** | - | - |

Significant at the 0.01 level **

It is evident that there is a correlation between each item and the total score of the scale, and that these correlations range between 0.826 and 0.424, which are positive and statistically significant at the 0.01 significance level.

(2) Using two terminal groups:

Again, the students' scores on the cognitive load scale were arranged in a descending order, after which the highest category was determined as 25% and the lowest category was 25%. Then, the averages of these two groups and their standard deviation were calculated, and the Mann Whitney scale was used to show the significance of the differences between the two averages on the total score of the cognitive load scale. Table 7 below shows the difference between these two groups:

**Table 7: Average ranks, total ranks and the Mann-Whitney value and its significance**

| | Categories | No | Average ranks | Total ranks | U | Z | (sig) | Significance level |
|---|---|---|---|---|---|---|---|---|
| Cognitive load scale | Highest category | 5 | 8 | 40 | 0.000 | 2.71 | 0.000 | Significance level at 0.000 |
| | Lowest category | 5 | 3 | 15 | | | | |

It is evident that there are statistically significant differences between the two groups, which favor the highest group. That is, the scale is valid, and its items have a good discriminatory ability among the examinees.

Scale reliability:
To ensure the reliability of the scale, reliability was calculated using Cronbach's alpha and Spearman-Brown coefficients with the validity and reliability sample. Table 8 below shows the reliability coefficients of the scale.

**Table 8: Reliability coefficients using Cronbach's alpha and Spearman-Brown**

| | Alpha-Cronbach's value | Spearman-Brown value |
|---|---|---|
| Total score of the scale | **0.7**13 | **0**.823 |

It is evident that the values reached by the researcher indicate that the scale has a high degree of reliability through the split-half method.

**4.4 Experimental treatment of Groups**
The experimental treatment was done in the experimental groups. A set of instructional design models for the design of technology for education was reviewed, including that by Al-Shaltout (2016) and the ADDIE model, and great similarities were found between them. Therefore, the ADDIE model was chosen due to the clarity of its steps and its relevance to the nature of the current research. This model consists of five stages: analysis, design, development, application, and evaluation (Al-Sherman, 2019). In the following, I provide an explanation of the steps followed in designing infographics of two patterns (static vs. dynamic):

1- Analysis: At this stage, the characteristics of learners, the learning environment, and the instructional content to be conveyed were analyzed. The analysis yielded the following:

- Characteristics of the learners: They were sixth grade (male and female) students in a private school in the state of Muscat, who received their education using the blended learning method, and whose ages ranged from 10-11 years. The developmental characteristics were common to most of the students at that age. More specifically, they loved movement and exploration, and their visual coordination appeared bigger and deeper. In addition, their ability to innovate, create and imagine was well developed, as was the ability to find and express relationships and solve problems. Of course, these attributes would contribute a lot to their receptiveness in relation to infographics technology. Prior to this study, the target group had not already received any instruction through infographics technology.

- Learning environment: This refers to the classrooms in which the materials would be presented to students, and their physical components; thus, the availability of computers and data display devices connected to them was checked. In addition, a safe atmosphere was provided while taking all precautionary measures, by ensuring the existence of appropriate lighting and ventilation. In addition, it was ensured that all students were able to access the school's education platform in order to obtain infographics through it.
- Instructional content: Analyzing the content of Part one of the science curriculum for the sixth grade, one of the lessons about the living organism's unit in the environment was chosen, which contained a group of similar, interrelated concepts that are often confused by students.

2- Design: During this stage, the content and the method of presenting it to students were determined. The outputs of this stage were as follows:

- Identification of instructional content:
  - The general objective was to identify food chains.
  - Instructional content: (1) the concept of food chains; (2) producing and consuming organisms in food chains; and (3) food chains in different habitats.
  - Behavioral objectives: (1) to understand the concept of food chains; (2) to list the components of food chains; (3) to connect and link between organisms in food chains; (4) to identify the types of food chains in different habitats; and (5) to design food chains according to the living organisms discussed.
- Strategies used: While delivering the instructional content, the researcher relied on self-learning through infographics technology, as well as on discussion strategy for presenting the basic content and achieving extensive comprehension.
- Materials and Tools: A classroom in the school selected was equipped with computers and a data display device, in addition to the possibility of accessing the school's learning platform in order to present infographics in two patterns to students.

3- Development: During this stage, the website Wepik was used to design the static infographics, while Vyond was used for the animated/dynamic infographics containing the aforementioned concepts. Both infographic designs aimed to convey the same concepts and content. The technical and educational standards of design that were presented in existing literature were taken into account.

4- Application: At this stage, the school and the target learners were selected while the design was finalised, with all the relevant requirements for application and administration (e.g., activities and graphic cards). In addition, the researcher determined the appropriate timing, which was the period during which students attended school based on an alternate attendance procedure in light of the repercussions of COVID-19 i.e., a week of actual attendance followed by a week of distant learning, and so on. The suitability of the educational environment for application was ensured.

5- Evaluation: After each stage, a formative evaluation was carried out in order to ensure the clarity of the outputs therein, and their appropriateness to be basic inputs for the next stage. The design was also submitted to some specialists in the Ministry of Education, including educators and designers, to ensure the integrity and clarity of the submitted content. In addition, the design of the two infographic patterns was tested in a pilot study by some students at the same level, who were not members of the selected research sample, in order to ensure their ability to understand the material through the chosen design and the clarity of its components from their perspective. After finalising the designs, the researcher was ready to administer and conduct the experiment to the target group.

### 4.5 Data Collection

After defining the research problem and objectives, the school where the research experiment would be conducted, was contacted. An appointment with the administration and the science teachers dealing with sixth-grade students was set in order to clarify the purpose of the research and its premises in an accurate manner. This meeting also served to discuss the teachers' experiences with infographics, and whether it was applied with the students at this stage or previous ones. It was agreed with the administration and teachers to equip an appropriate classroom with the aforementioned specifications. Also, the conditions of selecting the sample were agreed upon. Students were then selected for the two experimental groups from the same school, as the numbers required for the sample were available. After identifying students and obtaining approvals, the students were divided into two groups, randomly and regularly, such that the first group would consist of students who attended in the same week, and the second consisted of those who attended the week after. A date was set to conduct the experiment on the two groups, so that the first experimental group would learn via static infographics technology, which was presented to students in the assigned hall. Students were allowed to discover it, obtain data through it, listen to their interpretations, and discuss that. Then, the content was uploaded to the student platform to allow them to review it at any later time and date.

The next day, the research tools were disseminated, then the experiment repeated with the second experimental group - but using dynamic infographics technology. Again, the lesson was also uploaded on the platform. Through observation of the performance of students in both groups during and after presentation, students demonstrated clear motivation, attractiveness, and great interest. This was evident through the discussions conducted among students, and the rate and level of questions that students posed to teachers, especially after being presented with the infographics. Finally, the research tools were disseminated, the data gathered, and the test results and the scale for the two experimental groups were treated with statistical software.

## 5. Research Results

### 5.1 Testing the 1st hypothesis

To test or verify the validity of this hypothesis, an independent-sample T-test was used. This revealed the significance of the differences between the students of the first experimental group and those of the second experimental group on the visual thinking post-test, as shown in Table 9 below:

**Table 9: T-test value of the significance of the differences between the mean scores of students' achievement in both the 1st and 2nd experimental groups in the visual thinking post-test**

| | Group | No | SMA | STD Deviation | Freedom | T value | Significance Level |
|---|---|---|---|---|---|---|---|
| Visual Thinking Test | 1st Experimental | **20** | **14.20** | **2.16** | **38** | **8.30** | 0.0001 |
| | 2nd Experimental | **20** | **18.55** | **0.88** | | | |

It is clear that the value of T reached 8.30 at the probability value of 0.0001, which is smaller than the significance level adopted in this research study (0.05). Furthermore, there is a clear difference between the mean scores of the post-test for both groups in favor of the second group, where the SMA of the post-test for the first group was 14.20, while that of second was 18.55. This confirms the 1st hypothesis and indicates its validity. Therefore, the well-designed visual elements and movement in the dynamic pattern had the greatest effect in stimulating and activating the visual thinking processes of the research sample in the second group more than the first. Also, the characteristics of the sample group members, including their age and academic level, evidently have an effect on the response of this group to the dynamic pattern, since students with these characteristics have a natural tendency towards the moving elements in receiving knowledge, whether in the form of videos or animated cartoons. Liu and Elms (2019) emphasized that students increasingly demand engaging, customized multimedia content. Animation constitutes a powerful pedagogical tool by combining audio messages with tailored visual cues and graphics, to serve the dual functions of explaining complex concepts and engaging – and maintaining - student interest in the learning process. Additionally, it is possible that the nature of the target instructional content (i.e., the concept of food chains) and the relationship of this concept to living organisms contributed significantly to the success of the dynamic pattern in a greater development of the visual thinking skill. This result agrees with that of previous studies, such as Lievemaa (2017), Shafee et al. (2018), Muhammad et al. (2020), Barcelos & Azevedo (2020), Kaur (2020) and Song (2021), all of which indicated the effectiveness of dynamic elements in visual thinking skills development for learners.

**5.2 Testing the 2nd hypothesis**

To test and verify the validity of this hypothesis, an independent-sample T-test was used. This revealed the significance of the differences between the students of the two experimental groups on the post-administration cognitive load scale test, as shown in Table 10.

**Table 10: T-test value of the significance of the differences between the mean scores of students' achievement in both the 1st and 2nd experimental groups in the post-administration of the cognitive load scale**

| | Group | No | SMA | STD Deviation | Freedom | T value | Significance Level |
|---|---|---|---|---|---|---|---|
| Cognitive Load Scale | 1st Experimental | **20** | **29.70** | **4.26** | **38** | 10.78 | **0.0001** |
| | 2nd Experimental | **20** | **17.35** | **2.83** | | | |

The value of T reached 10.78 at the probability value of 0.0001, which is smaller than the significance level adopted in the research (0.05), while there is a significant difference between the mean scores of the Cognitive load scale test for both groups in favor of the 1st group. The mean score of the first group came to 29.70, while that of the second group was 17.35, which onfirms and indicates the validity of the second  hypothesis. Thus, the students in the first group students who were taught using the static infographics had a high cognitive load – in fact, up to double that of their peers in the second experimental group, who dealt with dynamic infographics. This confirms the ability of dynamic infographics in organizing the learners' cognitive load more effectively in learning while also reducing the perceptive and cognitive burden by giving learners broader opportunities for a deeper and more detailed understanding of the targeted knowledge through the features and advantages provided by dynamic infographics. At the same time, dynamic infographics allow learners to retain that knowledge and retrieve it with a simple mental effort and in a relatively short and quick time. This was also confirmed by Dina and Ensaf (2021), that indicated that the interactive (dynamic) infographic employs tablets and mobile devices that have proven to attract students' attention and motivate them to learn. These students learn patiently and pay careful and adequate attention to different components associated with interactive (dynamic) infographics and focus on the precise details. This will help them reduce their cognitive load and contribute to deeper and faster learning. This also agrees with the findings of many previous studies, the most important of which are Khalifa (2018) Aldalalah (2020), Hamid et al. (2020), Mustafa (2021), Chen (2020), and Gjoreski (2020). All of them indicated the effectiveness of moving or animated elements in reducing the cognitive load of learners.

## 6. Discussion

### 6.1 Dissections related to the first hypothesis

The results of the study show a clear difference in the arithmetic means between static infographics and dynamic infographics, which indicates the superiority of the latter in developing students' visual thinking. These findings are consistent with those of previous studies (e.g., Abdul Hamid et al., 2020; Muhammad et al., 2020), which showed the superiority of dynamic infographics in visual culture. This superiority can be attributed to the combination of sound, image and motion offered by dynamic infographics, which are compatible with different types of learners; students can follow this style in an integrated manner without isolating any of its properties (i.e. sound, image, and movement).

In addition, the sequential presentation used by dynamic infographics provides students with the ability to analyze the components step by step, which contributes to their understanding of the content and thus allows them to decode all the information presented. In this era of digital technology, this pattern represents a major factor in attracting learners' attention, who prefer to link movement, image, and accompanying sound effects, as they are accustomed to these things through their personal electronic devices, such as videos, and games. Lievemaa's study (2017) confirmed that dynamic infographics was a factor that attracts students' attention, and considered them an invaluable tool in their learning, and therefore, inclusion of dynamic infographics in education has become inevitable.

In general, the potential of dynamic infographics contributed to the development of students' visual thinking and their ability to analyze the forms, images and relationships presented to them, providing them with the ability to interpret the information step by step and reach the meaning that the infographic seeks to convey. Thus, it enabled them to deal with infographics in their own way and according to their abilities and at their own convenience. For example, students can stop or mute the sounds and look at the presentation only or listen to a certain part again in order to focus on what they want. All this gives a visual value to the students' concepts, which leads to their ability to retain information and concepts in a way that indicates understanding, as well as the student's ability to retrieve it every time they needed to.

Infographics offer many possibilities to simplify information and display it in a way that students can extract concepts from it in a manner commensurate with their abilities, remember it or retrieve it when needed. Students can read static infographics in an appropriate visual way by maximizing or minimizing parts of the screen, and scrolling right and left, then analyzing it and understanding its components, followed by extracting the relationships and understanding the whole picture, and thus deducing the general meaning of the infographic. Several studies have indicated that infographics, especially dynamic infographics, can provide in developing visual thinking skills. In this regard, Smolkowski et al. (2020) confirmed that the use of shapes and animated images contributed to improving the knowledge of group members relating to critical thinking concepts, their ability to teach those concepts, their knowledge of concepts related to argumentative writing and justification, and finally developing the actual ability to perceive and analyze tasks and to understand the characteristics used to convey concepts and meanings.

Ocobock (2020) also found that animated multimedia, like dynamic infographics, develops many skills among learners, the most important of which are visual thinking skills, which help learners to move learning outcomes towards the creativity phase.

Similarly, Sato and Hayama (2020) emphasized that watching short video clips, such as animated/dynamic infographics, allows learners to deepen their understanding by creating a concept map while watching this clip; creating that map allows learners to obtain the content interactively, helping them to learn through visual, reflexive, and active thinking methods.

Furthermore, Chen (2020) confirmed that videos and animations have significant and lasting effects on teachers' beliefs and self-efficacy if professional development programs are offered. This effect goes further to modifying and developing actual teaching behavior within the instructional situation. Another study by Aguillon and Monterola (2020) indicated that videos that are limited in their content and display time, such as dynamic infographics, contribute significantly to the development of thinking skills, especially visual thinking, among learners of science courses, especially chemistry. Averin et al. (2021) also agreed that animation within the framework of infographics works to develop students' visual thinking skills, especially in the early stages of education, in a broad and effective manner considering the needs and requirements of the education community in light of the pandemic. Alherz et al. (2020) further confirmed that visual thinking skills contribute to improving the understanding of visual images and lead to a significant improvement in mathematics, reading, and socio-emotional learning, and that infographic animated clips and cartoons can contribute to the development of these skills (i.e. visual thinking skills), provided that animation design and development are based on uncomplicated master frames and limited quantities of graphics, texts and effects.

**6.2 Dissections related to the second research hypothesis**

Regarding reducing the cognitive load for learners, the results of the study indicated the superiority of dynamic infographics over static infographics, and subsequently, understanding concepts and the ability to retrieve them without effort. This can be attributed to the capabilities and features that characterize the dynamic pattern as discussed above. This is consistent with Aldalalah (2020) that emphasized the preference of dynamic infographics over static infographics in reducing cognitive load. Similarly, Mustafa (2021) concluded that the role of dynamic infographics can facilitate and simplify information by 60% for students, which can be considered as a factor that enhances their cognitive load reduction.

Besides, the appearance of information in the form of sequential movements (slide after slide) so that each slide of the presentation carries part of the information or concept, accompanied by sound and commentary, prevents learners from being distracted and keeps their focus on the relevant segment. This reduces the amount of information that reaches the working memory so that it can be dealt with appropriately and transferred it to permanent memory. Moreover, the diversity in the dynamic infographics pattern renders it appropriate for different types of learners, so that it does not constitute effort for them to receive information and process it.

The effective role of dynamic infographics in reducing students' mental effort to learn gives them freedom and security while acquiring, memorizing, and understanding concepts. This is consistent with Hamid et al. (2020) that showed the role of this style in helping students assimilate Arabic grammar with freedom and enthusiasm consistently with their abilities.

Geng and Yamada (2020) and Thees et al. (2020) pointed out the important role that animated or dynamic images and figures play, regardless of the environment in which they are presented, in reducing perceptual or cognitive load as learners extract the target knowledge. Petko et al. (2020) also agreed that the lowest levels of cognitive load correspond to viewing images, drawings, and shapes that are animated or displayed at medium speeds that are close to natural motion. Similarly, Chen and Kalyuga (2020) stated that images, cartoons, and animations allowed learners to manage the process of improving their cognitive load in order to improve their learning, and here the instructional design of these images and animations plays an important role in the success of this improvement process. Sweller (2020) agreed and pointed out that technological media, primarily images and animations, contribute significantly to reducing the cognitive load of target students, while Çınar et al. (2020) indicated that dynamic images and animations often represent the easiest learning tasks that require low effort and cognitive load on the part of learners. Furthermore, Caskurlu et al. (2021) showed that instructional designers use animated and dynamic learning media, which focus primarily on reducing learners' cognitive load in Massive Online Open Courses (MOOCs) as much as possible. These types of courses (MOOCs) rely mainly on videos or animations in providing instructional content to the target group; more specifically, international platforms, such as edX, Coursera and Udemy, are entirely dependent on videos or small animations in the form of mini learning objects to provide instructional content in all courses. Finally, through communication and discussion with the teachers, it became clear that the use of infographics had a noticeable positive impact on the students' performance, while everyone – both teachers and students demonstrated enthusiasm and motivation to use infographics for these scientific concepts.

## 7. Conclusion and Recommendations

Considering the above findings, expanding the reliance on infographics in general and dynamic infographics in particular can provide interactive e-content that is highly compatible with the characteristics of the digital generation. It is expected presenting ideas in this manner will help not only with developing thinking and reducing cognitive load, but also increases academic achievement rates and develops many other skills they need.

A serious effort sthe dynamic infographic technology in education is highly recommended, because of its potential to attract students' attention and maximizes their desire to learn. Teachers should be trained to use the latest technologies available, especially relating to dynamic infographics. If possible, students also should be trained to design and produce infographics because this technology provides a link or connection between images, texts, sounds and movements. This supports their learning and enables them to find a way to learn that suits them. Furthermore, those responsible for planning and designing instructional curricula should be urged to introduce this technique in delivering knowledge to students in all academic courses.

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