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Design of an Infographic based on Participatory Online Learning and its Impact on Academic Achievement and Attitudes among High School Students in Computer Subject Through the Lens of Cognitive Load Theory

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Abstract: This study aimed to identify the design of an infographic based on participatory learning through the lens of cognitive load theory and its impact on academic achievement and attitudes among high school students in the computer subject. Following a quasi-experimental approach, 53 sophomore students in high schools in Abha City were randomly selected and distributed into two groups: a control group of 26 and an experimental group of 27. The study found that using infographics in computer subject lessons has enhanced students' academic achievement and attitude. The results demonstrated a significant difference (0.05) between the experimental and control groups in the average score of the achievement test. Further, the study results revealed statistically significant differences between the students' average scores in the experimental group and the control group on the post-test mean score of attitudes toward infographics in favor of the experimental group. Implementing infographics is recommended in cases where students' academic achievement and attitudes toward computer lessons are inadequate.

Keywords: Infographics, academic achievement, attitudes, participatory learning, cognitive load theory.

تصميم الإنفوجرافيك القائم على التعلم التشاركي عبر الإنترنت وأثره على التحصيل والاتجاهات لدى طلاب المرحلة الثانوية في مادّة الحاسب الآليّ في ضوء نظرية الحمل المعرفي

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المستخلص:

هدفَت الدّراسة إلى التعرف على تصميم الإنفوجرافيك القائم على التّعلّم التّشاركيّ عبر الإنترنت وفقاً لنظرية الحمل المعرفي وأثره في التحصيل الدراسي والاتجاهات لدى طلاب المرحلة الثانوية مادّة الحاسب الآليّ. طبق المنهجَ شبه التجريبي، على عيّنةٌ من (٥٣) طالباً من طلبة الصّفّ الثّاني الثّانويّ بمدينة ابها، وتم توزيعهم على مجموعتين: مجموعة ضابطة مكونة من (٢٦) ومجموعة تجريبية مكونة من (٢٧) طالباً. وتم أعداد اختبار تحصيلي في مادة الحاسب، ومقياساً للاتجاه نحو الإنفوجرافيك. وأظهرت نتائج الدّراسة بعد اختبار فروضه إحصائياً تفوّق طلّاب المجموعة التّجريبيَّة على طلّاب المجموعة الضّابطة، حيث خلصت الدراسة إلى وجود فروق دالّة إحصائيّاً عند مستوى الدّلالة (٠,٠٥) بين متوسّطي درجات طلّاب المجموعة التّجريبيَّة والمجموعة الضّابطة في القياس البَعديّ للاختبار التّحصيلي لصالح المجموعة التّجريبيَّة، كما كشفت نتائج الدّراسة عن وجود فروق ذات دالّة إحصائيّة بين متوسّط درجات طلّاب المجموعة التّجريبيَّة والمجموعة الضّابطة في المقياس البَعديّ للاتجاه نحو الإنفوجرافيك لصالح المجموعة التّجريبيَّة.

الكلمات المفتاحية: الإنفوجرافيك، التّحصيل الدّراسيّ، الاتجاه نحو الإنفوجرافيك، التّعلّم التّشاركيّ، نظرية الحمل المعرفي.

INTRODUCTION

Digital technology has revolutionized teaching and learning, transforming teachers from mere transmitters to facilitators and enabling learners to adapt, modify, participate effectively, and prioritize their abilities. Data visualization, also known as visual representations of information, is utilized to transform abstract data into visual forms to reinforce human cognition, helping learners or viewers understand the internal organization of the data as well as its causal relationships. An information graphic, or infographic for short, is one of the most widely used data visualization tools that efficiently conveys complex information, disseminates scientific research, and drives behavioral change through various forms of text, diagrams, and charts. Infographics aid learning by transferring knowledge and understanding relationships through drawings, shapes, static, and interactive images, consolidating concepts and ideas. Infographics are visualizations that combine graphics and text to convey information in an engaging and easy-to-understand manner (Dalton & Design, 2014); these visualizations are used for data interpretation.

According to Noh et al. (2015), infographics have a design in which data are combined with images to facilitate the dissemination of information. An infographic is "a visual representation of various information to understand complex information, data, and ideas quickly, easily, and simply' (Cifci, 2016, p. 155). Combining text and images enhances learners' ability to absorb and remember information more effectively than text alone. According to Yiidirim's (2016) study, an infographic is more effective and conducive to learning than text materials. Al-Mallah and Al-Hamidawi (2018) and Adi and Ariesta (2019) studies argued that the human brain's faster processing of images enables learners to quickly identify links and relationships and interpret messages, enhancing their ability to recognize patterns and comparisons.

When the working memory is overloaded with a large amount of information, what is known as cognitive load occurs, and the student's learning is weak (Ginns & Leppink, 2019). Any fatigue or overloading of mental capacity with a large amount of information leads to difficulty concentrating and attention. The cognitive load theory (CLT) indicates this as a load imposed on working memory while performing a task (Sweller et al., 2011, 2019).

Cognitive load impacts students' achievement and educational performance. Teaching students to reduce knowledge without losing it involves organizing and interconnecting new information to build cognitive schemas in their memory (Sweller et al., 2011, 2019); this is achieved through focus, attention, and repetition. Studies (Muhammad & Al-Saadi, 2018; Rashwan, 2021; Al-Shammari, 2015) have shown a correlation between working memory capacity and academic achievement, as it involves the amount of information that keeps students active and influential. Mental schemas play a crucial role in learning and acquiring knowledge.

Infographics are valuable in educational contexts, helping students focus, reducing cognitive load, and inspiring learning. Several studies have investigated the impact of infographics on education (Abbas & Al Jabas, 2020; Al Ghamdi & Al Zahrani, 2019; Al Samdani, 2019; Al Shawoush, 2019; Al Shehri, 2018; Al-Saleem, 2016; Ismaeel & Al Mulhim, 2021; Noh et al., 2015; Yildirim, 2016), emphasizing the fact that infographics help with the delivery of facts and scientific information in the form of visual information; they give students the chance to compare, reflect, and develop deductive thinking skills; they serve as a cognitive

foundation for those who cannot infer by reading texts alone; they also assist students in understanding and simplifying complex ideas and concepts.

According to Noh et al. (2015), infographics are widely recognized as powerful tools for precise information acquisition. Attiya (2020) and Barghouth (2022) highlighted the effectiveness of infographics in educational processes, transforming data into engaging images and graphics, improving memory and recall, and making information more appealing to readers. Çifçi's 2016 study found that infographics improve geography students' academic achievement by enhancing active learning and increasing recall rates, emphasizing their crucial role in teaching and mental activity. Likewise, Murad's (2021) study revealed that infographics significantly enhanced students' academic achievement in science.

Alrwele (2017) further stated that infographics effectively capture viewers' attention, aiding faster comprehension of complex information by creating mental models, simplifying perception, and connecting visual information to the real world. Bicen and Beheshti's (201٩) study revealed that students generally have a positive attitude towards using infographics in their classes, as they prefer visual materials over traditional textbooks. Uyan Dur (2014) found that infographics could help students improve their attitudes and life skills, in addition to their ability to increase academic achievement.

As an attractive tool, Sudakov et al. (2016) indicated that infographics could be implemented as a starting point for discussion and a culminating experience in authentic learning by allowing learners to demonstrate their ability to comprehend a topic and concisely summarize its central themes. Infographics convert information into visually appealing images, accelerate learning, facilitate sharing via social networks, save time, improve thinking, and aid information retention. Al-Saleem (2016) emphasized the effectiveness of infographics in aiding learners to organize ideas, visualize intricate relationships, compare information, and produce valuable data. Besides, Infographics have been proven to enhance engagement, memory retention, recall, comprehension, and communication skills (Shadyab et al., 2021; Hughes et al., 2021). Al-Mohammadi (2017) utilized infographics to teach computer programming basics, demonstrating their efficacy in enhancing learning, especially among students with advanced computer skills.

Gizawi and Barbari’s (2019) study shows that infographics are superior in teaching sociology, outperforming traditional methods. Likewise, Murad's (2021) study revealed that infographics significantly enhanced students' academic performance in science.

Infographics are essential for effective communication, information transfer, and interaction. Based on Çifçi's (2016) research, students who used infographics performed significantly better academically than those who did not. Alrwele (2017) stated that the positive impact of infographics on learners' learning experiences demonstrates their ability to enhance retention and understanding of subject-related material. Chicca and Chunta (2020) emphasized that infographics can be used in various learning environments, including classrooms and at any student level. Infographics visually convey expressive information about a topic, making it more understandable and appealing. Well-designed, visually appealing, and valuable infographics can convince and guide people.

The study on the impact of infographics on students' achievement and attitudes is crucial for several reasons. Therefore, this study can provide evidence-based practices, enabling researchers to assess the actual impact of infographics on student outcomes. The findings can

inform evidence-based teaching strategies and enhance instructional design. The study can also guide educators in designing engaging learning materials using infographics to enhance student achievement. It can identify specific student populations that may benefit most from infographics, such as those with different learning styles or struggling with traditional methods. Understanding the impact of infographics on student attitudes can help educators create learning experiences that foster positive attitudes, engagement, and a love for learning. This study contributes to the growing body of knowledge on effective instructional strategies, enhances educational practices, and informs decision-making in education.

PROBLEM STATEMENT

Computer subjects are one of the disciplines known for having a lot of knowledge and complexity that are hard for students to learn, comprehend, and absorb. As a result, students in this course could improve their attitude toward the computer subject. This was supported by a survey the researcher performed on forty high school students in Abha City to gauge how challenging the computer course was. According to the exploratory study results, the abundance of information and higher cognitive load cause 92% of students to feel bored in class. 22% of the students indicated that teachers' reliance on traditional teaching methods based on memorization is the reason for the difficulty. The results of the exploratory study are consistent with many studies on teaching methods and strategies that improve students' academic achievement, such as the studies of Al-Shehri (2018), Al-Shawish (2019), Al-Ghamdi and Al-Zahrani (2019), Al-Mohammadi (2017), which demonstrated the effectiveness and impact of infographics in the computer subject. These studies recommended studying the impact of infographics on students' academic achievement and attitudes.

According to Ismaeel and Al Mulhim (2021), infographics have enhanced academic achievement and motivation in various fields and disciplines, such as science (Abdul Ghani et al., 2019), mathematics (Al-Rahili, 2021; Barakat, 2022; Alshehri & Ebaid, 2016), educational media (Al-Buhairi, 2018); geography (Çifçi, 2016), social studies (Yeşiltaş & Cevher, 2018; Yıldırım, 2018), and computers (Al-Mohammadi, 2017; Al-Shawoush, 2019; Al-Ghamdi & Al-Zahrani, 2019), social studies (Al-Jizawi & Al-berberi, ٢٠١٩), and visual learning (Afify, 2018) emphasized the urgent need to adopt different modern strategies and methods in education. These studies recommended studying the impact of infographics on students' academic achievement and attitudes.

In several previous studies in education (e.g., Latif et al., 2018; Hammad, 2020; Suwayt, 2018; Al-Ghamdi & Afshi, 2018), infographics based on participatory online learning should be used, their application in teaching and learning processes should be carefully considered, and further studies in this area should be conducted.

Considering the aforementioned, it is clear that there is an actual issue, specifically a lack of academic achievement among sophomore students in the computer subject. Thus, the current study addresses this issue by exploring an infographic design based on participatory online learning and its impact on academic achievement and attitudes among high school students studying computers.

RESEARCH QUESTIONS AND HYPOTHESES

1. What impact does the design of infographics based on participatory online learning have on academic achievement among high school sophomores in computer subjects?

2. What impact does the design of infographics based on participatory online learning have on high school sophomores' attitudes towards infographics based on participatory online learning in the computer subject?

To answer these questions ,the following hypotheses were investigated:

H_1: There are statistically significant differences at level 0.05 between the average scores of the control and experimental groups on the academic achievement test in favor of the experimental group.

H_2: There are statistically significant differences at level 0.05 between the average scores of the control and experimental groups in the attitude toward infographics based on participatory online learning in favor of the experimental group.

THE SIGNIFICANCE OF THE STUDY

The significance of a study is to offer a theoretical framework for educational researchers and provide an effective method for teachers to use infographic design in participatory learning. It also aims to expand students' and researchers' horizons by following modern strategies in education, preparing teachers for the profession, and enhancing their performance in virtual classrooms. The research aims to expand the horizons of students and researchers in the field of education.

LITERATURE REVIEW

New technologies have revolutionized learning by providing visually appealing, concise information resources. Infographics are visualizations of data or ideas that convey complex information to an audience in a manner that can be quickly consumed and easily understood. Infographics, categorized into six types: static, zooming, clickable, animated, video, and interactive, enhance learning processes and present complex information. Infographics refer to visual representations of information, data, or knowledge designed to convey complicated concepts or data clearly and concisely. Graphics can enhance visual system perceptual abilities, allowing individuals to identify and comprehend trends and patterns through their representations easily. Khasawneh and Khasawneh (2023) highlighted the importance of infographics in concisely and understandably conveying complex information. Infographic technology is a method that combines the benefits of visual learning with traditional and integrated learning approaches. Almelewth and Alqahtane (2020) emphasized the importance of enhancing learning outcomes by fostering more robust connections between knowledge, images, and symbols and expanding information sources to maximize individual potential and achieve optimal results. According to Ismaeel and Al Mulhim (2021), infographics are valuable tools for presenting scientific ideas and skills that traditional teaching methods need help to convey, primarily scientific skills.

COGNITIVE LOAD THEORY (CLT)

Cognitive load theory (CLT) is an instructional theory based on our knowledge of human cognition (Sweller et al., 2011, 2019). CLT focuses on how the cognitive load, or mental effort required to process information, impacts learning. It has since become a popular framework in educational research. CLT suggests that effective instruction minimizes extraneous cognitive load and optimizes germane cognitive load. Since its establishment in the late 1980s, CLT has used aspects of human cognitive architecture to generate experimental instructional effects. These effects are demonstrated when novel instructional procedures are compared with traditional methods in a randomized, controlled experiment (Sweller et al.,

2011, 2019). Suppose the novel procedure facilitates learning based on test performance; a new effect may have been demonstrated, generated by our knowledge of human cognition. The new instructional procedures that follow from this effect become candidates for relevant professionals such as instructional designers and teachers.

According to Sweller et al. (2011, 2019), The interactions between information structures and knowledge of human cognition were used in CLT to determine the instructional design. This means that instructional design should reduce unnecessary cognitive load by providing learners with practical examples. Sweller argued that working memory load can be influenced by the intrinsic nature of learning tasks (intrinsic cognitive load) and how the tasks are presented (extraneous cognitive load). Instructional interventions cannot alter the inherent cognitive load because it depends on the interaction between the nature of the materials and the learners' expertise; however, the extraneous cognitive load can be altered by instructional intervention. Therefore, to reduce the working memory load, we can alter the extraneous cognitive load by presenting the information through two information channels (visual and auditory). Visual and auditory working memory are separated from each other. When information is presented in all visuals, such as written text and a diagram, the visual processor will be more overloaded than when information is presented in visual and auditory forms, such as written and spoken. Infographics can help students pay attention, reduce cognitive load, and inspire learning in educational settings.

CLT suggests that working memory is limited to processing information, and learners must mentally integrate new information with their existing knowledge. Overall, CLT illuminates how instructional design can improve learning by managing the cognitive demands placed on learners (Sweller et al., 2011, 2019). Using infographics in educational contexts can help students learn and perform better by lowering their cognitive load. When using infographics as a teaching tool, students retain more information and comprehend complex concepts more fully than when using only traditional text-based materials. Infographics have the potential to increase student motivation and engagement, thereby improving their academic performance. Infographics' impact on student achievement and efficacy will be further expanded by incorporating technology into their creation and presentation. Students with diverse learning styles and preferences will benefit from infographics visually representing information that supplements traditional textual learning materials. Including interactive infographics and multimedia elements in technology-based platforms improves student interaction and comprehension, resulting in higher achievement outcomes (Yarbrough, 2019).

ACADEMIC ACHIEVEMENT AND ATTITUDE

Extensive studies have been conducted on infographics and their impact on student's academic achievement and their attitudes toward infographics in educational institutions such as schools and universities (i.e., Afify, 2018; Al-Mohammadi, 2017; Noh & Son, 2015; Ozdal & Ozdamli, 2017; Saadah, 2019; Uyan Dur, 2014; Yarbrough, 2019). Uyan Dur's (2014) study on infographics in education reveals that they enhance academic achievement, develop life skills like research, systematic thinking, and teamwork, and improve hands-on learning, problem-solving, engagement, and reflective and creative thinking. Additionally, Noh et al. (2015) found that infographics positively contribute to students' academic achievement and attitude by improving their visual thinking and understanding of scientific concepts and communication skills. Further, the results of Murad's (2021) study on the effectiveness of using

infographics to promote academic achievement in science were consistent with the findings of Al-Jizawi and Al-Barbari's (2019) study on the advantages of using infographics in education for social studies in comparison to traditional teaching methods and raising students' academic achievement. The study by Alsoub (2021) examined using infographics in history instruction to improve visual thinking skills in eighth-grade students. A semi-experimental design was used, with 63 students, 31 in the experimental and 32 in the control group. The results showed significant differences in mean scores between the two groups. Moreover, Khasawneh and Khasawneh (2023) found that the experimental group had significantly higher post-test scores regarding academic achievement than the control group.

Ismaeel and Al Mulhim (2021) found that employing infographics improves academic achievement and increases learning motivation. Siddiq (2018) conducted a quasi-experimental study to determine the impact of using infographics in mathematics instruction on student achievement and the development of visual thinking abilities. The average accomplishment test results of the experimental and control groups differed significantly ($p < 0.05$) in favor of the experimental group. Cifci, (2016) and Ozdamlı et al. (2016) have demonstrated statistically significant differences between pre-and post-tests in favor of post-tests for students assessed using infographics. Its average was 22.07 versus those based on texts, and its average was 19.54.

According to Al-Buhairi's (2018) study, which employed a quasi-experimental methodology using infographics in the classroom, they had a significant and discernible impact on three levels of academic and cognitive achievement (understanding, remembering, and analyzing). Furthermore, Al-Ghamdi and Al-Zahrani (2019) found statistically significant differences in the development of educational achievement levels between students in the experimental group using infographic designs and students in the control group who studied conventionally, and these differences favored the experimental group at a significance level of 0.05.

Several previous studies have taken into account students' attitudes toward the use of infographics in learning (e.g., Abdul-Ghani et al., 2019; Alrewle, 2017; Çifçi, 2016; Kabooha & Elyas, 2018; Noh et al., 2014; Yildirim, 2016). For example, Bicen and Beheshti (2019) found that the experimental group was more enthusiastic about using infographics than the control group, and the authors indicated that students could learn faster and become more confident in the learning process. In his 2019 study, Abdul-Ghani et al. sought to understand how using infographics impacted science students' academic achievement and their attitudes toward learning the subject. The findings, obtained through a semi-experimental methodology, showed statistically significant differences in student achievement and attitudes regarding using infographics in science at the significance level (0.05) and important differences in improving student achievement in favor of the experimental group.

Alrewle (2017) studied the impact of infographics on student achievement and attitudes toward them in EFL classes. According to the collected data, approximately 90% of the students were positive about using infographics in EFL lessons. Furthermore, the Barakat study (2022) sought to investigate the impact of infographics in mathematics education on achievement and the development of reflective thinking among primary fourth-grade students. The researcher relied on a semi-experimental approach. The study found that the average scores of the experimental and control groups on the achievement test varied statistically significantly in favor of the experimental group. On the other hand, Ozel (2019) concluded that no significant

increase in achievement at all stemmed from the use of infographics when compared to the traditional method recommended in the science curriculum.

METHODOLOGY

Research Structure

A semi-experimental approach—a two-group pre-and post-test design—was used to investigate the independent variable (infographics based on participatory online learning) and dependent variables (academic achievement and attitude towards the infographics).

Population and Geographic Location

The study population consisted of all sophomores in high schools in Abha City (N = 702). The study sample was intentionally selected from the "First Abha High School" in Abha City. The sample size was 53 students, divided into experimental (n = 26) and control (n = 27) groups. The experiment was conducted during the second semester of the 2022–2023 academic year.

Measurement

1. ***Achievement Test***

An achievement test was developed to measure the cognitive aspect of computer subjects in unit two, "Information Data and Internet Security," of a computer textbook. The test considered the cognitive levels of Bloom's taxonomy (remembering, understanding, and analyzing). The validity of the content analysis was verified by a panel of arbitrators and experts (11), who provided their opinions on the suitability of the analysis for the unit's content. A specification table and relative weights were prepared, and ten items were distributed on three cognitive levels of Bloom's taxonomy.

Behavioral objectives were formulated following the nature of the study content as determined by the study experience, and five behavioral objectives were distributed over these three levels of Bloom's cognitive taxonomy. These objectives were presented to several experts to give their opinions on the accuracy of the formulation of behavioral objectives, their relevance to the material's content, and their suitability for sophomores in high school. In light of the observations made by experts, they were modified and finalized. The researcher prepared an objective, multiple-choice test. This type of objective test was selected because it is honest and objective, and it can measure and represent all cognitive objective levels while also accurately representing the subject matter.

The achievement test consists of formulated items, including an introduction that reflects behavioral objectives, measures cognitive levels, and serves as the backbone of vocabulary. The introduction can be information, a question, a report, or a drawing. Following the introduction, a set of choices or alternatives are presented, with the correct answer being determined by the probabilities of the right answer. The remaining incorrect choices are called distractors.

Developing test instructions:

The researcher formulated the test instructions after completing the development of their words. The instructions aimed to clarify the test's purpose, its components and parts, how to write general data, and how to answer the test questions. They considered clarity, appropriateness to the student’s level, and ease so that the students could understand how to respond. The test scores were determined by assigning one mark for the correct answer and nothing for the incorrect answer in each test item so that the maximum limit for the test became

ten marks and the minimum for the test was zero. The researcher ran an exploratory experiment on a random sample of twenty sophomore students to determine the test's validity and reliability coefficients, ease and difficulty coefficients for the test items, and discrimination coefficients. Understand the clarity of the test instructions and the meanings of the words.

The Validity of the Achievement Test

Face Validity: It is the simplest type of honesty, and it means judging the appearance of the items and questions of the data collection tool in terms of their connection to the field or topic to be measured, the suitability of the tool for the respondents, the clarity of the data collection instructions, and the correct arrangement of the tool's items and questions. The type of questions and their suitability for obtaining appropriate answers from the respondents (Abu Al-Nasr, 2004). This was confirmed during the individual and exploratory experimentation phases by administering the test to students at the same academic level who were not part of the primary research sample and discussing the clarity of the test questions. Also, change the wording of some questions that students had difficulty understanding.

Content validity refers to how well the items and questions in a data collection *tool accurately represent the field or topic being measured instead of face validity.* This necessitates the researcher defining the field or topic to be measured thoroughly and then developing a set of questions that cover this field or topic (Abu Al-Nasr, 2004), which was considered during the achievement test preparation.

The Validity of the Arbitration Agreement: After formulating the test questions and instructions in the initial form, which was sent to a panel of eleven arbitrators, specialists from the faculty members in the field of computers, curricula, teaching methods, and educational technology, to gain their opinions on the test questions in terms of the extent of scientific accuracy in formulating the test questions and the degree to which each question belongs to the behavioral. Based on these suggestions, some questions were reformulated to arrive at the final form distributed to the research sample, which included ten questions.

Internal Consistency Validity: The internal consistency reliability was determined by calculating the Pearson correlation coefficient *(r)* between the score of each test question and the total score for the level it contains. It was discovered that all correlation coefficient values were statistically significant, which is a strong indicator that the test has internal consistency and is suitable for application to the primary research sample, as illustrated in Table 1.

Table 1

Internal consistency and reliability coefficients for achievement test questions

Questions	*r*	*Sig*	*Questions*	*r*	*Sig*
Level of Memorizing					
١	0.898**	0.001	9	0.739**	0.001
٧	0.790**	0.001	10	0.726**	0.001
8	0.813**				
Level of Understanding					
3	0.810**	0.001	5	0.836**	0.001
Level of Analysing					
2	0.841**	0.001	6	0.814**	0.001
4	0.880**	0.001			

Table 1 shows that all achievement test questions were related to the overall score of the levels they were classified, with a statistically significant correlation at level (0.01). This

indicates that questions at all levels have a high level of reliability and can be trusted to measure what they were designed to measure.

The Split-Half and Kuder-Richardson 20 (KR-20) were also used to determine the test's reliability, as follows:

Split-Half Reliability: The achievement test reliability coefficient was calculated using the split-half method, and the results showed that the reliability value for the achievement test was 0.88, which is greater than the minimum acceptable reliability of 0.60. Thus, the test was highly reliable.

The Kuder-Richardson Formula (KR-20): The achievement test's reliability was further assessed by calculating the internal consistency coefficient between questions using the KR-20. The results showed that the achievement test's internal consistency coefficient was 0.87, higher than the minimum acceptable reliability of 060. The test had a high degree of reliability and was suitable for application in this study.

Analysis of Test Items:

Coefficient of difficulty of test items: The goal of calculating the difficulty score for the test items is to remove the items with a difficulty score of less than 0.20 or more than 0.80 (Abu Daqqa, 2008). The results revealed that the ease coefficients ranged between 0.30 and 0.50, and the difficulty was between 0.50 and 0.70, indicating that every test item was deemed statistically valid.

The Coefficient of Differentiation of Test Items: The purpose of calculating the discrimination coefficient for test items was to eliminate items with a discrimination coefficient less than 0.20 because they were considered weak in their discrimination among sample participants. The results showed that the achievement test questions ranged from 0.40 to 0.80; all test items were statistically acceptable.

Completion of the Achievement Test: The vocabulary of the achievement test was formulated in its final form after reviewing the opinions of the arbitrators and applying them, ensuring that the test is truthful and consistent, and statistically analyzing its vocabulary, which confirmed that the test is statistically acceptable in terms of ease, difficulty, and discrimination. To demonstrate the test in its final form, where the achievement test consists of ten multiple-choice questions with four alternatives and where the student is asked to choose the correct answer from four alternatives (a, b, c, d), the maximum score obtained by the student was ten.

Pre-Test for the Achievement Test: Before starting the experiment, the study groups were administered the final achievement test to measure their level of academic achievement in the computer subject. A t-test (Independent Samples T-test) was used to compare two independent groups and determine the significance of the differences between the average scores of the experimental and control groups in the achievement test pre-test. The exam was 45 minutes long and on paper, as shown in Table 2.

Table 2

The results of the t-value of two independent samples and its statistical significance verify the equivalence of the experimental and control groups in the tribal application of the achievement test.

The level	Application	Group	M	SD	t-value	Sig	Significance
Remembering	pre-test	Control	2.15	1.35	0.083	0.934	Not significant
		Experimental	2.11	1.5			
Understanding	pre-test	Control Group	1.22	0.751	0.513	0.61	Not significant

		Experimental	1.11	0.766			
Analyzing	pre-test	Control Group	1.22	1.12	1.036	0.306	Not significant
		Experimental	1.5	0.812			
Total	pre-test	Control Group	4.59	2.31	0.239	0.812	Not significant
		Experimental	4.73	1.87			

Table 2 indicates no statistically significant differences at the significance level (0.05) between the experimental and control groups in the pre-test of the achievement test at its levels, as t-values ranged between 0.083 and 1.036. Its statistical significance was more significant than the level significance ($0.05 \geq \alpha$), and this is an indication of the equality of the experimental and control groups in the level of academic achievement before starting the experiment, indicating that the experimental and control groups started learning from approximately the same level, and thus any change that occurs in the academic achievement can be traced back to the independent variable in the experiment.

2. Attitudes Scale

Determining the General Purpose of the Scale : The researcher built an attitude scale by determining its general purpose. The scale aims to reveal the homogeneity of the study sample members in their tendency toward using infographics by applying it pre-tested and investigating the effect of infographic design based on collaborative online learning on developing the tendency toward using infographics among students in the experimental group compared to students in the control group through its post-application.

Determining the Sources for Building the Scale: The scale's construction began in its first form by reviewing the literature regarding students' attitudes towards infographics (e.g., Al-Zahrani, 2020; Al-Shihri & Al-Adil, 2018; Al-Shawoush, 2019; Al-Ghamdi & Al-Zahrani, 2019).

Preparing the Initial Version of The Scale: The researcher derived many items that were suitable for preparing the initial form of the scale based on previous studies in which measures of close trends were mentioned, in addition to what resulted from the researcher's meetings with a group of students to reveal their perceptions about the utilization of infographics in their learning, as it resulted in a set of opinions that were formulated linguistically in a language that is easy for students to understand. The scale included four main dimensions and 22 sub-items, as follows:

- Infographic Characteristics: 8 items.
- The importance of the infographic: 6 items.
- The uses of infographics in learning computer subjects: 4 items.
- Enjoying the infographic ٤ :items.

Grading System: The responses to the items used in the current study are based on the five-point Likert scale (Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree). The responses correspond to the ratings (5, 4, 3, 2, 1) respectively. In contrast, the response score for each alternative to the negative items was given reverse scores according to the following sequence (1, 2, 3, 4, 5), and the scale's total score ranges between 22 and 110.

The Exploratory Experiment for Measuring the Attitude Toward Infographics: An exploratory experiment for the attitude toward infographics was conducted on a random exploratory sample of twenty sophomores in high school to determine the validity and reliability of the scale's internal consistency.

Verifying the Validity of the Attitude Scale: For the scale's validity, the attitude scale was sent to seven arbitrators and experts from the teaching staff in educational technology, curricula teaching, and methods to arbitrate and verify the veracity of the content of its composing paragraphs. The opinions and suggestions provided by the arbitrators were then considered, and the scale was prepared in its final form, consisting of 22 items.

Internal Consistency of the Scale: The items' correlation coefficients with the dimensions' total score were calculated using the Pearson correlation coefficient *(r). T*he results indicated that all the items that make up the scale were related to the dimensions in which they were classified with a statistically significant relationship when significance levels range between 0.05 and 0.01, as *(r)* for the items that make up the scale and the total score for the dimension within which it is classified ranged between 0.96 at its highest level in front of paragraph 21, and 0.51 at its lowest level before paragraph 12. , which indicates the strength of internal cohesion between the items and the dimensions in which they are classified. This is a strong indicator that the scale has internal consistency; the results are shown in Table 3.

Table 3

The reliability coefficients of the internal consistency of the metric

No. Items	The coefficient of correlation with the total degree of dimension	Sig	No. Items	The coefficient of correlation with the total degree of dimension	No. Items	Sig
The first dimension (Infographic Characteristics)						
1	0.809**	0.01	5	0.771**	5	0.01
2	0.884**	0.01	6	0.807**	6	0.01
3	0.790**	0.01	7	0.864**	7	0.01
4	0.795**	0.01	8	0.750**	8	0.01
The second dimension (The Importance of Infographics).						
9	0.651**	0.05	12	0.514*	12	0.01
10	0.602**	0.01	13	0.595**	13	0.01
11	0.593**	0.01	14	0.755**	14	0.01
The third dimension (Use of Infographics in Learning Computer Material)						
15	0.837**	0.01	17	0.943**	17	0.01
16	0.831**	0.01	18	0.836**	18	0.01
The fourth dimension (enjoy infographic)						
19	0.828**	0.01	21	0.963**	21	0.01
20	0.829**	0.01	22	0.882**	22	0.01

The Validity of the Hypothesized Construct: The validity of the hypothesized construct of the scale was checked by calculating the Pearson correlation coefficient *(r)* between the total score of the scale and its dimensions. The results showed that the dimensions that make up the scale were linked to its total score in a statistically significant relationship at the significance level (0.01), and (r) ranged between 0.745 and 0.946, which indicates a high level of validity in the hypothetical formulation of the scale, and this confirms its validity to measure what it was designed to measure. The results are shown in Table 4.

Table 4

The validity coefficients of the hypothetical configuration of the dimensions of the scale

Dimensions	*r*	*Sig*
Infographic characteristics	0.745**	0.01
The importance of infographics	0.946**	0.01
Uses of infographics in learning computer	0.769**	0.01
Enjoy the infographic	0.812**	0.01

Verifying the Reliability of the Attitude Scale: This was calculated using Cronbach's alpha (α) equation. The results indicated that the reliability coefficients were appropriate, as the highest reliability coefficient was on the "characteristics of infographics" dimension at 0.92, while the lowest was on the "importance of infographics" dimension at 0.67. The reliability coefficient on the scale's total score was 0.92, all above the limit. The minimum acceptable reliability was 0.60, and it can be concluded that the scale had a high degree of reliability, so it can be relied upon to obtain accurate results when applied to the primary study sample. The results are shown in Table 5:

Table 5

Results of Cronbach's Alpha reliability coefficients for the infographic attitude scale and its dimensions

Dimensions	*Items*	*α*
Infographic characteristics	8	0.92
The importance of infographics	6	0.67
Uses of infographics in learning computer	4	0.85
Enjoy the infographic	4	0.89
The total score of the scale	22	0.92

Producing the Final Form of the Attitude Scale Towards the Infographic in Its Final Form: The infographic attitude scale included four main dimensions, and 22 sub-items were applied in the final form to both study groups to identify the attitudes of sophomores in high school toward using infographics before they started the experiment.

Pre-Measurement of the Attitude Towards the Infographics Scale: To verify the equality of the two groups in this variable, a t-test was used to compare two independent groups (Independent Samples T-test) to reveal the significance of the differences between the average scores of the experimental and control groups in the pre-measurement of the scale, the results demonstrated that there were no statistically significant differences at the level of significance (0.05) between the experimental and control groups in the pre-test of the attitude towards infographics scale with its dimensions, where the t-value ranged from 0.14 to 1.38, and its significance was more significant than the significance level (0.05), and this is an indication of the equality of the experimental and control groups on the scale of the trend toward infographics before the start of the experiment. Accordingly, any change in the trend toward infographics among second-year secondary school students can be returned to the independent variable in the experiment (infographics based on online participatory learning). The results are shown in Table 6.

Table 6

The test (t) results of two independent samples and their statistical significance verify the equivalence of the experimental and control groups in the tribal application of the infographic attitude scale.

Dimensions	Application	Groups	*M*	*SD*	t-value	Sig	Significance
Infographic characteristics	Pre-test	Control	21.63	3.25	0.573	0.569	Not significant
		Experimental	21.15	2.77			
The importance of infographics	Pre-test	Control	15.85	2.14	0.551	0.584	Not significant
		Experimental	16.19	2.35			
Uses of infographics in learning computer material	Pre-test	Control	11.11	2.48	1.014	0.315	Not significant
		Experimental	10.5	1.84			
Enjoy the infographic	Pre-test	Control	10.33	2.56	1.378	0.174	Not significant
		Experimental	11.31	2.59			
Total	Pre-test	Control	58.92	5.59	0.141	0.889	Not significant
		Experimental	59.15	6.21			

RESULTS AND DISCUSSION

1. *Results of the first Hypothesis*

The results of the answer to the first hypothesis, which stated: *"There is a statistically significant difference at a significance level (0.05) between the average scores of the control and experimental groups on the achievement test in favor of the experimental group,"* To verify the validity of this hypothesis, the arithmetic means (*M*) and standard deviations (*SD*) of the student's grades in the experimental and control groups were calculated. The results revealed significant statistical differences between the means using a t-test to compare two independent groups, "control and experimental," the analysis results are shown in Table 7.

Table 7

Arithmetic averages, standard deviations, test results (t), and the size of the effect (η2) of the differences in the dimensional application of the achievement test between the two study groups

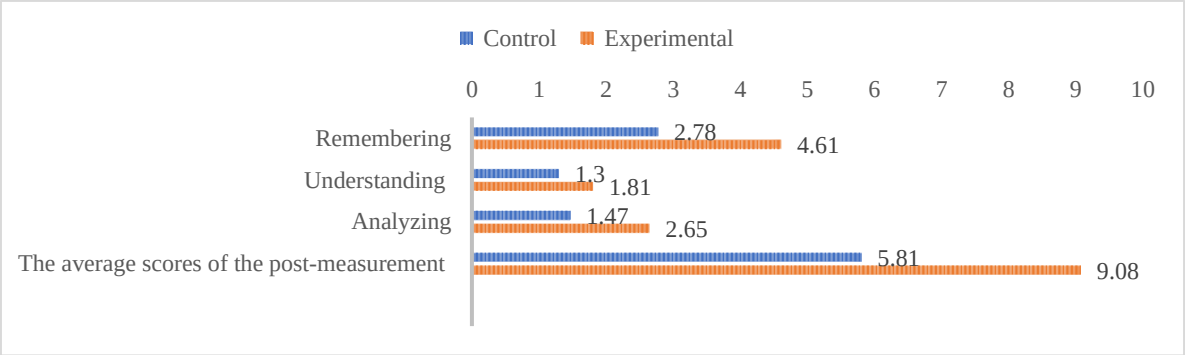
Level	Application	Group	M	SD	T-Value	Sig	Significance	η2 (Impact size)
Remembering	Pre-test	Control	2.78	1.25	6.776	0.000	Significant	0.47 (Big)
		Experimental	4.61	0.637				
Understanding	Pre-test	Control	1.3	0.724	3.194	0.003	Significant	0.17 (Big)
		Experimental	1.81	0.402				
Analyzing	Pre-test	Control	1.74	1.06	4.058	0.000	Significant	0.24 (Big)
		Experimental	2.65	0.485				
Total	Pre-test	Control	5.81	1.88	7.962	0.000	Significant	0.55 (Big)
		Experimental	9.08	0.977				

The results shown in Table 7 show that there were statistically significant differences at the level of significance (0.05) between the average scores of students in the two groups—experimental and control—in the post-measurement of the achievement test, where the T-value for the total score was 7.962 and its significance was less than the permissible level of significance (0.05), the arithmetic mean of the experimental group reached 9.08 and the control group 5.81 out of the total score 10. The result is that the mean of the experimental group is greater than the mean of the control group, and the direction of the significance of the differences is in favor of the higher mean; the direction of the differences is in favor of the experimental group, which means accepting the hypothesis that states: *"There is a statistically significant difference at the level of significance (0.05) between the average scores of the control and experimental groups in the post-application of the achievement test in favor of the experimental group*.".

It was also found that there were statistical function differences in the significance within the sublevels of the achievement test in telemetry between the experimental and control study groups, where the T-value ranged between 3.2 and 6.8. Their statistical significance was less than the limit of the permissible significance level (0.05), which indicates the presence of differences between the averages of the telemetry scores within the cognitive levels of the achievement test (remembering, understanding, and analyzing). The differences were in favor of the experimental group. These results are represented graphically in Figure 1.

Figure 1

Arithmetic averages of the scores of the experimental and control groups on the post-measurement of the achievement test



As given in Figure 1, the value of (η2) on the total score of the achievement test was 55%, which is the ratio of what the independent variable *"infographic based on participatory online learning"* explains of the total variance of the dependent variable (computer academic achievement), and ranged for sublevels between 17% and 47%, which indicates that the independent variable is directly responsible for the differences between the two groups and that it has a significant impact on the development of students' academic achievement in the experimental group, both in the cognitive sub-levels and in the overall grade of the achievement test. Then, black-modified gain ratios were calculated according to the Black equation, which indicates whether the independent variable is influential over the dependent variable in the students of the experimental group. By comparing the scores of the students in the experimental group on the achievement test in the pre-and post-measurements and considering the high score of the achievement test, the results are shown in Table 8.

Table 8

The percentage of black's adjusted gain in the experimental group within the pre-and post-test measurements of the achievement test

Group	Application	*M*	*SD*	The grand finale of the test	Black modified gain ratios	Statistical level
Experimental Group	Pre-test	4.73	1.87	10	1.26	Acceptable
	Pro-test	9.08	0.977			

It is clear from the results of Table 8 that the percentage of the Black modified gain ratios in the experimental group in the pre-and post-measurements of the achievement test amounted to 1.26, which means that the proposed experimental treatment material (*infographic based on participatory online learning*) had a high degree of effectiveness in developing academic achievement, as Black believes that the percentage must not be less than 1.2 for the effectiveness of the method to be considered acceptable. Therefore, employing infographics based on participatory learning in computer teaching has already contributed to developing the academic achievement of the computer subject among students. Consequently, the answer to the first question, "*What impact does the infographic design based on participatory online learning have on academic achievement among sophomores in high school?"* was determined.

The results demonstrated the impact of using an infographic based on participatory online learning on sophomore high school academic achievement. The results determined a statistically significant difference at the significance level (0.05) between the average scores of students in the experimental and control groups in the post-measurement of the achievement test at its levels (remembering, understanding, analyzing, and the total score). The differences

favored the experimental group that used the infographic based on participatory online learning. These findings reinforce the suggestions made by earlier studies that an infographic is a valuable teaching tool that has the potential to enhance students' academic achievement (i.e., Al-Shehri, 2018; Alshawosh, 2019; Alrwele, 2017; Aydemir, 2021; Uyan Dur, 2014; Elaldı & Çifçi, 2021; Ozdal, Ozdamli, 2017). These results are also in line with the findings of Shawish's study (2019), which showed that the independent variable had a significant impact as the value of η2 reached 0.45, meaning that the independent variable had a significant impact, as well as the results of Barakat's study (2022), which found that using infographics significantly affects students' academic achievement in mathematics. On the other hand, the study's results contradict some earlier studies, such as Ozel's (2019), whose results found no significant difference in academic achievement between students who used infographics and those who did not.

2. ***Results of the second Hypothesis***

The results of the answer to the second hypothesis, "*There is a statistically significant difference at the significance level (0.05) between the average scores of the control and experimental groups in the post-application of the attitude towards infographics scale in favor of the experimental group,"* This hypothesis was tested by computing the arithmetic means (M) and standard deviations (SD) of the student grades in the experimental and control groups. The results were compared using a t-test to compare two independent groups (the experimental and control) and showed statistically significant differences between the means. Table 9 illustrates the findings.

Table 9

The arithmetic averages, standard deviations, test results (t), and trace size (η2) of the differences in the dimensional application of the infographic attitude scale between the two study groups are shown.

Dimensions	*Application*	*Group*	*M*	*SD*	*t-value*	*Sig*	*Significance*	η2 (Impact size)
Infographic characteristics	Pro-test	Control	22.48	6.72	9.821	0.000	significant	٠.65 (Big)
		Experimental	36.04	2.46				
The importance of infographics	Pro-test	Control	16.22	3.62	15.404	0.000	significant	٠.82 (Big)
		Experimental	27.61	1.27				
Uses of infographics in learning computer material	Pro-test	Control	11.04	2.31	14.107	0.000	significant	٠.79 (Big)
		Experimental	18.77	1.63				
Enjoy the infographic	Pro-test	Control	11.63	2.42	12.831	0.000	significant	٠.76 (Big)
		Experimental	18.85	1.57				
The total score on the scale	Pro-test	Control	61.37	9.34	20.044	0.000	significant	٠.89 (Big)
		Experimental	101.27	4.37				

According to the analysis results given in Table 9, there is a statistically significant difference at the significance level (0.05) between the post-measurement of the attitude scores of the experimental and control groups (t-value = 20.044).

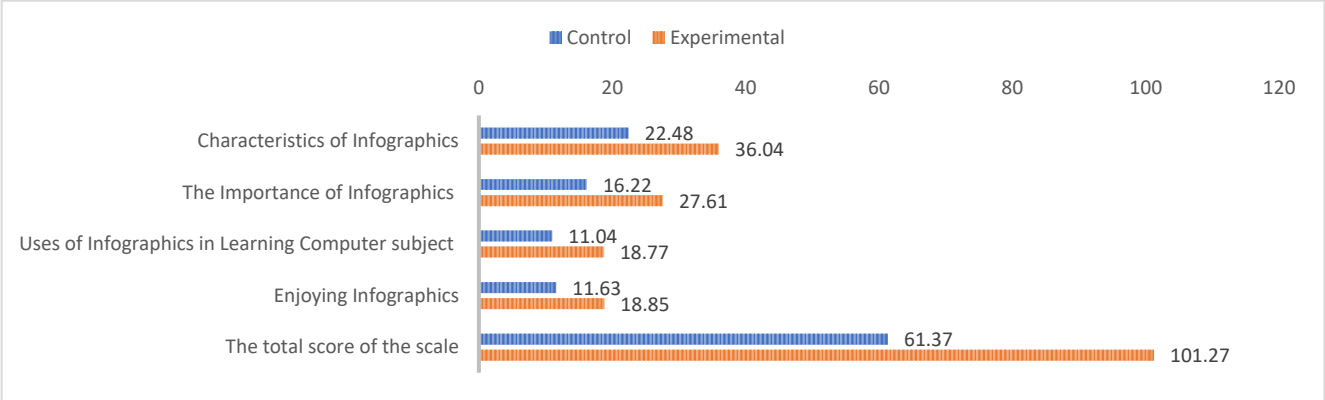
Its statistical significance is beyond the limit of the permissible significance level (0.05). The arithmetic means of the experimental group reached 101.27, and the control group reached 61.37 out of the total score of 110. The result is that the mean of the experimental group is higher than the mean of the control group and that the attitude of the significance of the differences is in favor of the higher average. Hence, the direction of the differences favors the experimental group, which means accepting the hypothesis: *"There is a statistically significant difference at a significance level (0.05) between the average scores of the control and*

experimental groups in the post-application of the scale." The attitude towards infographics was in favor of the experimental group.

The post-measurement analysis revealed that, in the sub-dimensions of the attitude towards the infographics scale, there was a statistically significant difference between the experimental and control groups at the significance level (0.05). The t-value of this difference, which varied between 9.8 and 15.4, had a statistical significance lower than the relevant level (0.05), which shows that there was a difference in favor of the experimental group between the average scores of the post-measurement at the level of the sub-dimensions of the attitude towards infographics scale (characteristics of infographics, its importance, its uses in computer science education, and its enjoyment). These results are represented graphically in Figure 2.

Figure 2

Arithmetic averages of the scores of the experimental and control groups on the post-measurement of the attitude towards infographics scale.



As given in Figure 2, the value of η2 on the overall score of the infographic attitude scale reached 0.89, which is the ratio of what the infographic based on participatory online learning explains from the total variance of the attitude towards the infographics and ranged for sub-dimensions as between 0.65 and 0.82, which indicates that infographics based on participatory online learning are directly responsible for the differences between the two groups, which has a significant impact on the development of the experimental group's attitude towards the infographics, both in terms of sub-dimensions and in the overall degree of the infographic orientation scale.

The earnings ratio was computed using Black's equation to determine whether infographics are effective based on participatory online learning over attitudes toward them in the experimental group. Table 10 compares the experimental group's students' attitude scale scores regarding infographics to the attitude scale's significant degree of consideration.

Table 10

The percentage of blacks' adjusted gain in the experimental group within the pre- and post-measures of the infographic attitude scale

Statistical level	*Black's earning rate*	*The great end of the scale*	*SD*	*M*	*Application*	*The collection*
Acceptable	1.21	110	6,21 4.37	59.15 101.27	Tribal Dimension	Empiricism

Table 10 shows that the percentage of Black-adjusted gain in the experimental group within the pre- and post-measurements of the attitude towards infographics was 1.21. This indicates that the infographics based on participatory online learning, which are the subject of the proposed experimental treatment material, are very effective in changing how high school sophomores feel about infographics. As a result, using infographics based on participatory

online learning in computer teaching has already influenced sophomores' high school attitudes toward infographics. Therefore, the answer to the second question, "*What impact does the infographic design based on participatory online learning have on the attitude towards infographics among sophomores in high school?"* was determined. The results revealed that there was a statistically significant difference at the level of significance (0.05) between the average scores of the students of the experimental and control groups in the dimensional measurement of the scale of the attitude towards infographics with its dimensions—the characteristics of infographics, the importance of infographics, the uses of infographics in learning computer material, enjoying infographics—the overall score of the scale. The differences were in favor of the experimental group.

The results indicate that sophomores' academic achievement and attitudes in high school computer classes were significantly low before the experimental processing subject's implementation. This could be attributed to traditional teaching methods. The experimental group's use of infographics based on participatory learning increased academic achievement and attitudes toward infographics. This is because infographics based on participatory online learning contain a variety of stimuli that attractively present information, pique students' interest, and make them want to repeat engaging learning experiences. The results indicate that sophomores' attitudes towards using infographics in high school computer classes were significantly low before the experimental processing subject's implementation. Students' attitudes toward infographics may differ depending on their preferences, learning styles, and prior experiences. Students' attitudes toward infographics can change depending on their preferences, learning styles, and experiences. In this study, students found infographics visually appealing and engaging, and they appreciated how infographics simplify complex information and make it easier to understand and remember; they perceived infographics as a valuable tool for learning and communication.

Additionally, students had a neutral stance toward infographics and acknowledged their usefulness in presenting information visually, but they may not have a strong preference for or against them. CLT principles can be effectively implemented through infographics as a valuable tool in instructional design. Infographics can simplify complex concepts, organize information logically, highlight key points, visualize relationships, incorporate mnemonic devices, engage dual coding, and provide just-in-time information. By condensing complex information into visual representations, infographics reduce the extraneous cognitive load associated with deciphering dense text or complicated diagrams. They also help students prioritize attention, reducing the cognitive load associated with processing irrelevant or extraneous information. Incorporating mnemonic devices, such as acronyms or visual cues, helps learners remember and recall information, reducing cognitive load. Dual coding theory suggests combining visual and verbal information to enhance learning and retention. Infographics can distribute cognitive load across multiple channels, leading to better comprehension. Lastly, infographics can provide just-in-time information, reducing the cognitive load associated with information retrieval. However, their design and content should align with CLT principles to avoid clutter and confusion. Care must be taken to ensure the visuals and information are clear, focused, and aligned with instructional goals to manage cognitive load and enhance learning effectively. These results align with other research (i.e., Bicen & Beheshti, 201٩; Çifçi, 2016; Dur, 2014; Ismail, 2016; Shahri, 2018) that revealed that besides their role in augmenting students'

academic achievement, infographics could enhance students' attitudes. The results corroborate the findings of a study by Bicen and Beheshti (2019), which found that the experimental group had a more positive attitude than the control group on the use of infographics. Furthermore, consistency in terms of the positive impact of infographics on achievement was also supported by previous studies (i.e., Afify, 2018; Al-Mohammadi, 2017; Hassan, 2016; Ozdal & Ozdamli, 2017; Saadah, 2019; Yarbrough, 2019). Likewise, Noh and Son (2015) stated that infographics contribute positively to students' academic achievement and attitude by improving their visual thinking skills and understanding of scientific concepts and communication skills.

CONCLUSION AND RECOMMENDATIONS

When information is to be given along with visuals in a computer lesson, infographics can be widely and effectively used across various learning areas and grade levels. Infographics can be successfully and extensively implemented in computer subject lessons at various grade levels and learning fields when graphics and information are presented together. The study findings validated the hypotheses and showed a statistically significant difference between the experimental and control groups of students. This study's findings indicated that using infographics based on participatory online learning positively impacted students' academic achievement. There was a statistically significant difference between the experimental and control groups, in favor of the experimental group, who were taught using infographics. Furthermore, the students in that group had positive attitudes toward using infographics.

As one of the best data visualization tools for improving students' attitudes and academic achievement, infographics based on participatory online learning should be encouraged to be incorporated into high school computer teachers' lessons. They are giving curriculum developers a guide on using infographics based on participatory online learning and the necessary steps to create computer lessons that consider the proper context, activities, and procedures.

Infographic-assisted instruction enhances student academic achievement. It should include design activities, in-service training, and free digital tools for teachers. More research is needed to determine its effectiveness in computer textbooks and syllabuses. National studies should be conducted on various subjects and participatory learning methods to motivate high school students' academic achievement.

The study is of great significance as it will provide a theoretical framework for researchers in the educational field to review and benefit from in their educational research and to contribute to providing officials with practical ways to hire teachers for the skill of graphic design using participatory learning in education, as it tries to expand the horizons of students and researchers through the teaching profession, which should be as effective as they need, and try to raise the performance level of teachers enrolled in the program within their virtual classrooms.

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