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Infographics as Multimodal Tools in Language-Based Learning: Enhancing Cognitive-Linguistic Skills in Secondary Education

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ABSTRACT

The study aimed to explore the use of infographics as multimedia tools in language-based learning: enhancing cognitive language skills in secondary education. The researcher used the quasi-experimental approach and the study community consisted of all tenth-grade students in public schools in Giza District, numbering (1272) male and female students. The study sample consisted of (100) male and female students. The experimental group consisted of two groups, one group consisting of (20) male students from Netl Secondary School for Boys, and (26) female students from Netl Secondary School for Girls. The control group consisted of two groups, consisting of (26) male students from Umm Qusayr School for Boys, and (28) female students from Umm Qusayr Secondary School for Girls. They were selected using the available random method (2024/2025 AD). The results of the study showed that there were statistically significant differences attributed to the post-test of computational thinking skills in favor of the experimental group, and that there were statistically significant differences attributed to the effect of teaching with infographics. The differences were in favor of teaching (the experimental sample) with infographics for the study unit designed in light of infographics. This means that the effect of the designed educational unit was high. The results showed that there were no statistically significant

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differences attributed to the effect of the interaction between the group and gender. The study recommends training social studies teachers on designing and employing infographic technology.

Keywords: Multimodal Discourse; Visual Literacy; Cognitive-Linguistic Skills; Infographics

1. Introduction

The current century has witnessed unprecedented technological transformations that have reshaped educational practices and redefined the roles of institutions in preparing learners for cognitively demanding, linguistically rich environments. As digital communication evolves and knowledge becomes increasingly visual and multimodal, there is a growing demand for pedagogical approaches that move beyond traditional text-based instruction—especially within content-based language learning contexts^[1]. This shift places emphasis on equipping students not only with disciplinary knowledge but also with cognitive-linguistic competencies that enable them to interpret, process, and communicate complex information effectively. In this context, infographics have emerged as powerful multimodal tools that combine visual literacy and language processing to enhance meaning-making^[2]. They serve as semiotic systems that merge images, symbols, and text into coherent visual narratives, facilitating deeper understanding and knowledge retention^[3]. Rather than merely decorative visuals, infographics support conceptual abstraction, narrative sequencing, and symbolic interpretation—all of which align with contemporary frameworks in multimodal discourse and cognitive linguistics^[4]. As part of the broader educational discourse, infographics offer a dynamic medium through which learners can engage with abstract concepts, especially in subjects that integrate language, thinking, and data representation. This pedagogical affordance becomes particularly significant in developing cognitive-linguistic skills, such as pattern recognition, information synthesis, and algorithmic reasoning, which are essential not only for language learning but also for navigating complex linguistic and visual texts in the 21st-century learning ecosystem. The present study, therefore, explores the impact of infographics within a language-based learning environment on enhancing secondary students' cognitive-linguistic skills, using a quasi-experimental design that bridges visual communication with educational linguistics Al-Sa'oub^[5], Majeed and Hussain^[6], and Oz-

damli and Ozdal^[7]. Marks and Thomas^[8] define it as a unique method for presenting qualitative and quantitative data and complex information in the form of visual information graphics such as (images, shapes, symbols, drawings, and texts)^[9]. What distinguishes a successful infographic are its design criteria, such as defining the objective of the infographic design, ensuring that the topic is suitable for conversion into an infographic, and identifying the components that can be utilized in the design, including images, shapes, graphs, and colors, and this is achieved through analyzing the content of the lesson topic, verifying the accuracy and currency of the information, Steinicke^[10] determining the type of infographic to be designed, considering the sequence and flow of information, and selecting attractive colors that are appropriate for the idea and objective, and simplicity and a lack of complexity in the design should be taken into account, so that the information is presented in a manner that allows the learner to easily and simply understand the topic Yildirim^[11], Al-Dayri, Al-Rabaani, Ibrahim^[12], believe that the features of infographics make them a suitable educational strategy for teaching subjects related to social and national education, as they encompass multiple topics that include abstract and complex concepts, which may pose a significant challenge for teachers in presenting them in a simplified manner to students who struggle to understand and apply them in real-life situations, which prompted those concerned with the educational process to find mechanisms that present the scientific material in a simplified and attractive manner for students, to increase their interaction within the classroom and motivate them to acquire knowledge, thereby overcoming the problem of low academic achievement and weak motivation in learning social and national education^[13]. Parveen and Husain^[14] emphasize the importance of infographics as one of the preferred teaching tools that are frequently used in the teaching process. Ahmad, Abdul Rahaman, Abdullah, et al.^[15] believe that visual data has gained significant acceptance as an educational tool for acquiring knowledge, as a means to convey complex ideas and concepts, and as one of the methods to address the problems arising from

students' limited ability to concentrate for extended periods of time, and its significant impact on students' academic achievement; as it helps them understand the subject matter, enhances their disciplinary skills, and develops their higher-order thinking skills (analysis, synthesis, and evaluation). Wang, Callaghan, Bernhardt, et al.^[16] mention several characteristics that distinguish infographics, including: visual appeal, coding and summarization, the ability to engage, the capacity to enhance the learning process, the ability to improve information processing, retention, and retrieval, and the development of certain ethical and social values among students through their presentation in lessons, contributing to the development of learners' personalities^[17-19]. Abdul Aziz and Rahab observe that the brain processes images more easily than written material, whether in mental processing, storage, or retrieval. An image condenses many details into words, as it can express the development of an idea, an event, or a process. Therefore, it is stored for longer periods in long-term memory and is more resistant to change and alteration. Thus, it is essential for the teacher to provide the opportunity for the student to read, discuss, and understand images and shapes, equipping them with a visual language that enhances their ability to communicate and comprehend the events around them, where images and illustrations are characterized by their ability to convey facts and abstract ideas visually, and they also aid in comparing objects to clarify similarities and differences. It is agreed by all that the objectives of using infographics in the educational process lie in simplifying complex and unfamiliar information and concepts for students, summarizing content, generating knowledge and information, and presenting it in an engaging and simplified visual format; in a manner that aids in the comparison of the presented information and its analysis effectively, facilitating the analysis of the messages and ideas within the content, revealing complex relationships, and making them easier to understand and remember. Visual elements allow students to learn at a pace that suits them and facilitate the learning process, such that they can be used to provide essential information about a topic, to add new information, or to confirm existing information. Infographics are also used as an alternative educational element to ordinary text materials. Due to the importance of the subject of the study, the study by Ahmad, Abdul Rahaman, Abdul-lah, et al.^[15] aimed to reveal the effectiveness of using static

infographics in a blended learning environment to develop concepts of digital citizenship and visual thinking skills in Saudi Arabia. The study sample consisted of (26) female students from the Department of Early Childhood at Umm Al-Qura University, and to achieve the study's objectives, a content analysis card was designed for the educational computer course, along with designs for static infographics, and a number of tools and applications for the blended learning environment. Additionally, a test for the concepts of digital citizenship and a test for visual thinking skills were administered, with their validity and reliability confirmed. The study results indicated statistically significant differences in favor of the experimental group. Al-Faqra^[20] conducted a study aimed at investigating the impact of a teaching unit based on visual learning on the development of picture reading skills and motivation towards learning geography among eighth-grade female students in Jordan, the study sample consisted of (48) eighth-grade female students in Amman, who were evenly distributed into two groups (an experimental group and a control group), the experimental group was taught the unit based on visual learning, while the control group studied the same unit using the conventional method. To collect data, the study applied a test of picture reading skills and a motivation scale towards learning geography, and the results showed statistically significant differences in favor of the experimental group, except for the skills of analysis and inference, and there were statistically significant differences in the motivation scale in favor of the experimental group. The study by Aguilar and Panoy^[21] aimed to identify the impact of infographics as a supplementary educational tool in developing scientific knowledge among distance learners in the Philippines. The study sample consisted of (30) seventh-grade students from public high schools in San Pablo City, and the results showed that the use of infographics as an educational tool led to an improvement in the respondents' scores regarding scientific knowledge, content knowledge, and procedural knowledge, as well as enhancing learners' skills. While Al-Sa'oub^[5] conducted a study that revealed the effect of employing infographic-based learning in teaching the subject of history on the development of visual thinking skills among eighth-grade students in Karak Governorate, the study was applied to a random sample consisting of (63) students, who were divided into two groups: an experimental group of (31) students who were taught using infographics,

and a control group of (32) students who were taught using the conventional method, and to achieve the study's objectives, a visual thinking test was developed, and the results of the study showed statistically significant differences in favor of the experimental group. Aguilar and Panoy^[21] conducted also a study aimed at identifying the effect of using infographics on students' achievement in the area of learning "global connections" in the social studies curriculum in Turkey, the study sample consisted of (37) fifth-grade students from the city of Artvin, divided into two groups: the experimental group, which included (19) students, and the control group, which included (18) students, and the results showed that infographic-based instruction positively impacts students' academic achievement, with statistically significant differences in favor of the experimental group. The study conducted by Aydemir^[22] aimed to reveal the effect of employing panoramic infographics in developing certain visual thinking skills in social studies among second-grade preparatory students in the Sharqia Governorate of Egypt, the study was applied to a sample consisting of (70) male and female students from the second-grade technical preparatory class, distributed between the experimental and control groups, and to achieve the study's objective, a visual thinking skills test was prepared. The results of the study indicated the presence of statistically significant differences in the post-application of the visual thinking skills test in favor of the experimental group, and the presence of statistically significant differences for the experimental group in the visual thinking skills test in favor of the dimensional application. Al-Faqra's^[20] study also aimed to reveal the effectiveness of using infographics based on visual perception in developing health concepts among kindergarten children in light of the Corona pandemic in Jordan, the study was applied to a sample consisting of (100) boys and girls in kindergartens in the city of Aqaba, and the results showed statistically significant differences in the dimensional application of the health concepts development test in favor of the experimental group, as well as statistically significant differences attributed to the effect of gender in favor of females, and statistically significant differences attributed to the interaction effect between the infographic-based teaching method and gender.

Commenting on previous studies and their relationship to the current study indicates that the previous studies varied in terms of objectives, methodology, type of study popula-

tion and sample, and the location of their implementation, all studies related to infographics agreed on its importance as a visual communication tool and an effective teaching method in the educational process, and they provide an engaging, exciting, and stimulating learning environment for students and contribute to enhancing attention, perception, memory, visualization, and imagination processes, which increases their positive attitudes toward educational content, as seen in the studies by Al-Sharif and Al-Subaie^[19], Al-Faqra^[20], Aguilar and Panoy^[21], Al-Sa'oub^[5], Aydemir^[22], Al-Marsafi^[23], Al-Gherbawy^[24], While a review of previous studies indicates that there is a variety in the use of methodologies, for example, the study of Al-Sharif and Al-Subaie^[19], the study of Al-Faqra^[20], the study of Aguilar and Panov^[21], the study of Al-Sa'oub^[5], the study of Al-Marsafi^[23], and the study of Al-Gherbawy^[24] all adopted a quasi-experimental methodology.

1.1. Study Problem

Education today is witnessing an urgent need to shift from traditional teaching methods—which often rely on text-based instruction—to more dynamic, multi-media strategies that align with the cognitive abilities, competencies, and skills requirements of the modern century. Despite recent advances in curriculum development, many educational practices are still based on traditional methods that make learners passive recipients of information, limiting their engagement and deep cognitive processing. One area where this development is evident is the use of visual tools to support language-based learning. While the digital generation is increasingly exposed to multimedia content outside the classroom, mainstream education still struggles to integrate visual and semiotic resources—such as infographics—as tools to develop learners' visual literacy and cognitive-linguistic skills, such as abstraction, pattern recognition, sequencing, and conceptual mapping. These skills are essential not only for understanding the curriculum but also for fostering advanced problem-solving abilities and meaning-making through language. As a result of numerous observations by researchers, there is a lack of focus on the use of infographics as multimedia discourse tools in secondary education, particularly in content areas where students are expected to interpret and process complex information. This gap highlights an opportunity to enhance students' ability to understand and retain information through symbolic visual communication

and develop their computational thinking within a rich linguistic context. Accordingly, the study addresses the limited use of multimedia visual tools in language-based instruction and the need to explore their impact on the development of linguistic cognitive competencies. The study seeks to explore how the integration of infographic techniques can enhance students' engagement, comprehension, and higher-order thinking skills within a pedagogical framework based on applied linguistics and visual awareness.

1.2. Study Questions

The first question: Are there statistically significant differences at the significance level ($\alpha = 0.05$) between the mean scores of tenth-grade students on the cognitive-linguistic skills test attributed to the instructional method (infographic-based vs. traditional instruction)?

Second question: Are there statistically significant differences at the significance level ($\alpha = 0.05$) in the scores of the linguistic cognitive skills test among tenth grade students attributed to the teaching method (infographic and traditional), gender, and the interaction between them?

1.3. Objectives of the Study

—To identify the effectiveness of using infographic techniques in teaching as a means of enhancing linguistic cognitive skills among tenth-grade students, and to measure this by revealing differences in their performance in tests compared to the traditional method.

—Demonstrating the existence of statistically significant differences at the level of statistical significance ($\alpha = 0.05$) between the average performance of students in the computational thinking skills test attributed to the variables of the study unit (infographic and regular) through gender and the interaction between them.

1.4. Importance of the Study

The importance of the current study arises from investigating the effectiveness of infographics in developing computational thinking skills among students and keeping pace with modern global trends that advocate for the enhancement of visual literacy in geography, generating knowledge, equipping students with skills through visual stimuli, and promoting the

culture of using infographics in the educational field. The current study adds a new dimension by presenting a practical model for employing infographics and computational thinking skills in geography, as it addresses computational thinking skills and enriches Arabic databases by providing a list of computational thinking skills that tenth-grade students should acquire in geography. The significance of the applied study lies in highlighting some information and concepts in an engaging manner that increases student motivation and contributes to the retention of learning outcomes, it also guides supervisors and teachers of social studies towards the role of educational units designed in light of infographics in developing computational thinking skills and various concepts among students, enhancing their motivation to learn, and drawing the attention of those responsible for developing geography activities to the necessity of employing visual means.

1.5. Study Determinants

The results of this study are determined by a set of determinants, which are:

—**Human, spatial, and temporal determinant:** This study was conducted on tenth-grade students in the second semester of the academic year (2023–2024) in the government basic schools affiliated to the Directorate of Education of the Giza Brigade.

—**Objective (procedural) determinant:** The results of the study were limited to the sincerity and stability of the study tool that the researchers prepared and developed, represented by the preparation of a test for computer thinking skills in light of the study variables (gender).

1.6. Terminological and Procedural Definitions of Study Terms

Infographics: Bicen and Beheshti^[25] define infographics as informational designs that represent complex information and data through visual graphics, aiming to present them in a simplified and clear manner.

The researcher defines them as the transformation of written texts in the educational unit into a visual representation of data, information, and concepts that combines images, shapes, graphics, and short texts in a simple, organized, and engaging printed format Verma^[26].

Computational Thinking: Palts and Pedaste^[27] de-

fine computational thinking as a set of thinking patterns and a method for problem-solving that represents a fundamental skill in life. It involves the logical arrangement and analysis of data, and the creation of solutions using algorithms and reasoning to solve complex and open-ended problems.

Visual Literacy: A comprehensive set of abilities that enable students to effectively interpret, evaluate, and encode visual content. These include critical, ethical, reflective, and creative engagement with visual media (such as images, graphs, charts, maps, icons, memes, and animations)^[28].

Computational Thinking Skills: The American Computer Science Teachers Association (CSTA), in collaboration with the International Society for Technology in Education (ISTE), defines computational thinking as a process for problem-solving. This process encompasses several elements that formulate problems in a way that enables the use of computers to assist in solving them, generalizing the benefits of the problem-solving process, and applying it to a wide range of issues.

Selby^[29] sees it as a way of thinking about problems in a manner that leads to executable solutions through a computer. It includes programming skills, algorithm design, and the abstraction of ideas.

The researcher defines computational thinking skills as a set of higher-order thinking abilities that help tenth-grade students solve problems through seven sub-skills: sequencing, abstraction, generalization, analysis, selection and debugging, pattern recognition, and algorithmic thinking.

Geography Curriculum: A curriculum book containing topics to be studied by tenth-grade students, as prescribed by the Ministry of Education in Jordan for the academic year 2023–2024.

Multimodal Discourse: Communicative practices through which multiple semiotic modes—such as text, image, sound, video, gesture, and spatial visualization—are

combined to construct meaning in digital and non-digital environments Sommer and Bembnista^[30].

Basic Stage: This includes students of the tenth grade in schools under the jurisdiction of the Giza Education Directorate, Ministry of Education in Jordan, for the academic year (2023–2024).

2. Study Methodology

The researcher employed a quasi-experimental method, aiming to answer the study questions, as this method is deemed most suitable for such studies.

2.1. Method and Procedures

This chapter presents an overview of the study curriculum, its community, and its sample, as well as the study tools, the design procedures, and their validity and reliability, along with its variables, practical procedures, and the statistical methods that were used.

2.2. Study Community

The study community consisted of all tenth-grade students in the government schools affiliated with the Directorate of Education in the Giza Brigade, totaling (1272) male and female students, the study sample comprised (100) students, with the experimental group consisting of two sections: one section with (20) male students from Netl Secondary School for Boys, and (26) female students from Netl Secondary School for Girls, the control group also consisted of two sections, with (26) male students from Um Qsair Secondary School for Boys, and (28) female students from Um Qsair Secondary School for Girls, and **Table 1** shows the distribution of the study sample members according to their variables.

Table 1. Distribution of Study Sample Members by Variables.

Variables	Gender	Iteration	Percentage
Gender	Male	46	46%
	Female	54	54%
Total		100	100%

2.3. Study Sample

The study sample consisted of (100) male and female students from the tenth grade in the government schools

affiliated with the Directorate of Education for the Giza Brigade during the second semester of the academic year (2023–2024). They were selected using a convenient ran-

dom sampling method and were divided into four groups as follows:

Experimental Group: The experimental group consisted of one class, comprising (20) female students from Netl Secondary School for Boys, and (26) female students from Netl Secondary School for Girls. The experimental group studied the fourth unit (Environmental Issues), according to the unit designed in light of the infographic.

Control Group: The control group consisted of two classes, comprising (26) male students from Um Qsair Secondary School for Boys, and (28) female students from Um Qsair Secondary School for Girls. It should be noted that the control group studied the same unit.

2.4. Study Material

The educational unit designed in light of the infographic: The fourth educational unit from the geography textbook for the tenth grade was titled (Environmental Issues), where the educational unit consisted of three lessons, and to design the unit in light of the fixed infographic, the following procedures were implemented:

- Reviewing the theoretical literature and previous studies related to static infographics and computational thinking skills.
- Defining the general objective of the design, which is to reveal the impact of designing an educational unit in light of infographics on the development of computational thinking skills among students.
- The fourth unit from the geography textbook for the tenth grade was selected, titled: (Environmental Issues), as a proposed unit for design purposes. The educational unit was designed in light of infographics, and computational thinking skills were incorporated within the designed unit, which include: (skill of sequencing, skill of abstraction, skill of generalization, skill of analysis, skill of selection and error correction, skill of recognizing relationships, skill of algorithmic thinking). Based on the above, the researchers followed five main stages in designing the educational unit in light of static infographics; these are:

First: Analysis Stage: This stage forms the cornerstone for all other stages of instructional design, through which all factors surrounding the learning environment are

identified and analyzed. This stage included the following procedural steps:

1. **Identifying the problem:** Assessing the needs related to the study problem, based on the results and recommendations of previous studies, extracting the skills and knowledge addressed by the course objectives, and discussing student grade records with the teachers responsible for teaching the course; to describe the current and desired situation, and to identify the educational needs of the study sample which were addressed using static infographics in the learning environment.
2. **Identification of learner characteristics:** The general characteristics of the study sample have been identified; they are: tenth-grade students, where the experimental group consisted of two sections, one section with (20) male students from Nablus Secondary School for Boys, and (26) female students from Nablus Secondary School for Girls, the control group consisted of two sections, with (26) male students from Um Qsair Secondary School for Boys, and (28) female students from Um Qsair Secondary School for Girls, and four sections were selected and distributed randomly into two experimental groups and two control groups, and pre-tests were administered to them.
3. **Identification of general and specific objectives:** The aim of using static infographics is to develop computational thinking skills among tenth-grade students.
4. **Identification of the source of deriving the fundamental concepts** to be developed among Tenth-Grade Students by referring to studies, research, and literature related to that field.
- **Identification of computational thinking skills** based on theoretical literature and previous studies, totaling (7) skills: (skill of sequencing, skill of abstraction, skill of generalization, skill of analysis, skill of selection and error correction, skill of recognizing relationships, skill of algorithmic thinking).
5. **Verification of the validity of these concepts by presenting them to a number of reviewers** in the fields of curricula and teaching and educational technology, with the aim of soliciting their opinions on these concepts and the accuracy of their linguistic formulation, and incorporating the referees' feedback into modifications of the concepts.

6. **Identification of the type of infographic:** The current study identified the type of infographic used, which is a static infographic.
7. **Determination of the internal structure of the static infographic** according to the nature of the educational content of the geography curriculum, taking into account the selection of simple, appropriate, and readable fonts, and determining suitable colors for the targeted content, ensuring harmony between the text color and the background, while avoiding distracting colors.
8. **Identification of shapes and visual elements** that are educationally appropriate for the target audience, adhering to the teachings of Islamic law, and avoiding unclear visual elements that may cause confusion.

Second: Design Stage: This stage aimed to determine the technical specifications and the procedures for implementing the study experiment, and this stage included the following procedures:

1. Formulating procedural objectives in the form of specific and clear behavioral statements, such that they represent an observable and measurable educational outcome.
2. Designing the static infographic by rephrasing and organizing the educational content to facilitate its visual representation.
3. Designing learning strategies and teaching methods by alternating between traditional classroom teaching using (data projection screens, lectures, dialogues and discussions, self-learning, and collaborative learning), and teaching using static infographics.
4. Designing educational activities that consider achieving educational objectives and assist in developing computational thinking skills, while taking into account the individual differences among students. These activities varied between individual and group activities, with some of them presented traditionally using paper and pen, and some consisting of electronic home activities, along with providing reinforcement and immediate feedback.
5. Constructing the study tool represented by the pre-test and post-test for computational thinking skills.

Third: Production Stage: This stage aimed at the technical specifications and procedures specific to the design

stage of educational materials, through the compilation of elements of visual educational content; to produce the formal prototype, and to conduct a technical review of the prototype; to ensure the visual representation of the educational content, the sequence of information, the accuracy of the utilized elements, and the integrity of the language.

Fourth: Implementation Stage: This stage aimed at the practical application of static infographics in the learning environment, executing it within the specified time for each lesson, continuously monitoring all stages and steps, and providing support and development for the learning environment, starting with the implementation of a pilot experiment on (25) students from the study population, outside the sample of the study; to calculate reliability, followed by the pre-application of the study tool, and preparing the students to participate in the study experiment, concluding with its execution and monitoring student performance, guiding, and directing them.

Fifth: Evaluation Stage: This stage aimed to determine the extent to which the study's objectives were achieved, to refine the study material and its tool, to make necessary amendments, and to ensure its integrity by presenting it to a group of specialized reviewers in educational technology, curricula, and teaching methods, totaling (10) faculty members from Jordanian universities. The designed educational content was applied to an exploratory sample consisting of (30) students outside the study sample; to conduct a pre-evaluation of the infographic, and a final evaluation was carried out.

2.5. Authenticity of the Developed Educational Content

The researcher subjected the designed unit to peer review prior to the implementation phase by specialists in the field of social studies curricula and their teaching methods, totaling (12) reviewers. Modifications were made based on their suggestions and opinions to ensure the validity of the educational outcomes included in the lessons designated for application to the experimental group in terms of: ease of use by the learner, suitability of the activities and exercises to the content and their comprehensiveness, and appropriateness of the amount of information presented in each part of the educational content. The observations and modifications provided by the reviewers were duly considered during the

implementation of the educational unit.

2.6. Study Tool (Computer Thinking Skills Test)

The purpose of the test was to measure the computer thinking skills of tenth-grade students (the study sample). To determine the sources of derivation for the test skills, the researcher referred to educational literature and previous studies related to computer thinking skills, selecting the most important computer thinking skills appropriate for this age group, which are:

1. Formulating test items for computer thinking skills in light of the computer thinking skills from the unit (Environmental Issues) in its preliminary form, which consisted of (7) questions.
2. The performance levels of the students on the computer thinking skills test were assessed objectively, where the researchers employed a quantitative assessment method, establishing performance levels corresponding to each skill.

Validation of Computer Thinking Skills Test: To verify the apparent validity of the Computer Thinking Skills Test, it was presented to a group of specialized referees from the teaching staff at Jordanian universities in the fields of social studies curricula and educational technologies, totaling (12) reviewers, their opinions were sought regarding the formulation of the items and sentences, as well as the appropriateness for the age group addressed in the study, their suggestions for rephrasing or adding new items were taken into account, and modifications were made in light of their

feedback until the test reached its final form, consisting of (7) questions.

Construct Validity: To extract the construct validity indicators for the test, correlation coefficients between the test skills and the overall test were obtained from a sample outside the study sample, consisting of (25) students, the skills of the test were analyzed, and the correlation coefficient for each skill with the overall test was calculated, representing an indicator of validity for each skill.

It appears from **Table 2** that the correlation coefficients of computational thinking skills with the test as a whole ranged between (0.50 – 0.71). The range (from –1 to 1) indicates the strength of the relationship between the study variables, where (1+) indicates a strong positive relationship, while (–1) indicates a strong negative relationship, and zero indicates no correlational relationship between the variables.

Stability of the computer thinking skills test: To verify the stability of the test, a test-retest method was employed by administering the test and re-administering it after two weeks to an exploratory sample outside the study sample, consisting of (25) students, and the Pearson correlation coefficient was calculated between their scores in both instances, and the reliability coefficient was also calculated using the internal consistency method (Cronbach Alpha coefficient), and **Table 3** illustrates this.

Table 3 shows that the internal consistency coefficient of the test as a whole was (0.72), and the transactions ranged between (0.70–0.74), and the stability coefficient of repetition of the test as a whole was (0.81), where it ranged between (0.79–0.85), which are acceptable values for the purposes of this study.

Table 2. Correlation Coefficients between Computational Thinking Skills and the Test as a Whole.

Number	The Skill	Correlation Coefficient with the Test
1	The skill of sequencing and arranging	0.50
2	Abstraction skill	0.66
3	Generalization skill	0.71
4	Analysis skill	0.54
5	The skill of selection and correction of errors	0.59
6	Pattern and relationship recognition skill	0.53
7	Algorithmic thinking skill	0.55

Table 3. Cronbach Alpha Internal Consistency Coefficient and Repetition Stability for Computational Thinking Skills and Testing as a Whole.

Skill	Internal Consistency	Replay Stability
The skill of sequencing and arranging	0.73	0.82
Abstraction skill	0.71	0.80

Table 3. Cont.

Skill	Internal Consistency	Replay Stability
Generalization skill	0.70	0.79
Analysis skill	0.72	0.81
The skill of selection and correction of errors	0.72	0.83
Pattern and relationship recognition skill	0.73	0.81
Algorithmic thinking skill	0.74	0.85
The test as a whole	0.72	0.81

Coefficients of difficulty and discrimination: The coefficient of difficulty and discrimination was calculated for the items of the computer thinking skills test, and Table 4 shows that:

Table 4. Difficulty and Discrimination Coefficient for Computational Thinking Skills.

Paragraph Number	Content of Test Paragraphs	Coefficient of Difficulty	Discrimination Coefficient
1	The skill of sequencing and arranging	0.63	0.44
2	Abstraction skill	0.80	0.56
3	Generalization skill	0.85	0.60
4	Analysis skill	0.69	0.47
5	The skill of selection and correction of errors	0.63	0.44
6	Pattern and relationship recognition skill	0.65	0.45
7	Algorithmic thinking skill	0.61	0.43

It appears from Table 4 that the difficulty coefficients for the paragraphs ranged between (0.61–0.85), and the discrimination coefficients ranged between (0.44–0.60). Where Odeh (2010) indicated that the acceptable range for paragraph difficulty is between (0.20–0.80), as for the discrimination coefficient, he noted that an paragraph is considered to have a good discrimination coefficient if it is higher than (0.39), acceptable if the discrimination coefficient ranges between (0.20–0.39) and should be improved, and if the discrimination coefficient ranges between (0–0.19), it is recommended

to delete it, and therefore none of the test paragraphs were deleted based on the difficulty and discrimination coefficients.

Equivalence of groups for the computer thinking skills test in the pre-test: To verify the equivalence of the groups, the arithmetic means and standard deviations for the Computer Thinking Skills Test in the pre-test were calculated, according to the variable of the group (experimental and control), and to demonstrate the statistical differences between the arithmetic averages, the “T” test was used, and Table 5 illustrates this:

Table 5. Application of the “Independent Samples T-test” on Students’ Scores in the Pre-Test for Computer Thinking Skills According to the Variable of Group.

Skill	Collection	Arithmetic Average	Standard Deviation	Value of “T”	Degrees of Freedom	Statistical Significance
The skill of sequencing and arranging	Control	1.35	0.89	-0.771	98	0.442
	Experimental	1.50	1.03			
Abstraction skill	Control	0.70	0.54	-0.822	98	0.413
	Experimental	0.80	0.69			
Generalization skill	Control	0.98	0.76	-0.668	98	0.506
	Experimental	1.09	0.81			
Analysis skill	Control	1.39	0.79	1.166	98	0.246
	Experimental	1.22	0.66			
The skill of selection and correction of errors	Control	1.48	1.14	0.405	98	0.686
	Experimental	1.39	1.06			
Pattern and relationship recognition skill	Control	1.80	0.94	0.067	98	0.946
	Experimental	1.78	1.09			
Algorithmic thinking skill	Control	1.11	0.72	1.088	98	0.279
	Experimental	0.98	0.45			
The test as a whole	Control	8.98	2.74	0.399	98	0.691
	Experimental	8.76	2.77			

It is evident from **Table 5** that there are no statistically significant differences at the significance level ($= 0.05$) attributed to the effect of the group (experimental and control) in all computer thinking skills and the total score in the pre-test, indicating the equivalence of the groups.

Correction of Computer Thinking Skills Test: Students' responses to the computer thinking skills test for the tenth grade were corrected, consisting of (7) questions, with each question awarded (3) marks for each correct answer, totaling (21) marks.

2.7. Study Design

A (pre-post) design was followed for four groups (experimental and control) of tenth-grade students, as illustrated in the following table:

2, B2	X	1, B1
2, B2	O	1, B1

Whereas:

1, B1: Pre-test of computational thinking skills for two groups.

1, B1: Post-test of computational thinking skills for two groups.

X: Implementation of the educational unit using the conventional method.

O: Implementation of the educational unit designed in light of the infographic.

2.8. Study Variables

The study variables have been classified as follows:

Independent Variable:

- **Gender:** It has two categories: (Male, Female).
- **Educational Unit:** It has two categories: (Infographic, Traditional).

Dependent Variable: Computer Thinking Skills.

2.9. Statistical Methods

Arithmetic averages and standard deviations were used, along with Multivariate Analysis of Covariance (MANCOVA), One-Way Analysis of Covariance (ANCOVA), T-test Independent Samples, and Two-Way Analysis of Covariance (ANCOVA).

3. Study Results and Discussion

This section of the study presents the results obtained by the current study, as follows:

3.1. The Results Related to the First Question State

The first question: Are there statistically significant differences at the significance level ($\alpha = 0.05$) between the mean scores of tenth-grade students on the cognitive-linguistic skills test attributed to the instructional method (infographic-based vs. traditional instruction)? To answer this question, the arithmetic averages and standard deviations (and adjusted arithmetic averages) of the scores of tenth-grade students on the computer thinking skills test were extracted, according to the variable of the group (experimental and control), and **Table 6** illustrates this:

Table 6. The Arithmetic Averages and Standard Deviations of the Scores of Tenth-Grade Students on the Computer Thinking Skills Test, according to the Teaching Method Using Infographics and the Traditional Method.

Skill	Collection	Number	Pre-Measurement		Post-Measurement		Average Adjusted	Standard Error
			Arithmetic Average	Standard Deviation	Arithmetic Average	Standard Deviation		
The skill of sequencing and arranging	Experimental	46	1.35	0.89	2.52	0.62	2.56	0.11
	Control	54	1.50	1.03	1.59	0.86	1.56	0.10
Abstraction skill	Experimental	46	0.70	0.54	2.28	0.66	2.27	0.10
	Control	54	0.80	0.69	1.41	0.69	1.42	0.09
Generalization skill	Experimental	46	0.98	0.76	2.26	0.65	2.27	0.11
	Control	54	1.09	0.81	0.94	0.83	0.93	0.10
Analysis skill	Experimental	46	1.39	0.79	2.59	0.54	2.66	0.11
	Control	54	1.22	0.66	1.69	0.95	1.62	0.11
The skill of selection and correction of errors	Experimental	46	1.48	1.14	2.65	0.60	2.65	0.12
	Control	54	1.39	1.06	1.61	1.04	1.61	0.11

Table 6. Cont.

Skill	Collection	Number	Pre-Measurement		Post-Measurement		Average Adjusted	Standard Error
			Arithmetic Average	Standard Deviation	Arithmetic Average	Standard Deviation		
Pattern and relationship recognition skill	Experimental	46	1.80	0.94	2.43	0.54	2.46	0.11
	Control	54	1.78	1.09	1.70	0.92	1.68	0.10
Algorithmic thinking skill	Experimental	46	1.11	0.72	2.43	0.78	2.50	0.11
	Control	54	0.98	0.45	1.46	0.79	1.41	0.10
The test as a whole	Experimental	46	8.98	2.74	17.17	2.32	17.38	0.43
	Control	54	8.76	2.77	10.41	3.48	10.24	0.40

It appears from **Table 6** that there are significant differences between the arithmetic averages and the adjusted arithmetic averages of the grades of tenth-grade students in the computer thinking skills test, due to the difference in the group variable (experimental and control), and it was found that the differences favored the experimental group that was exposed

to the study unit in light of the infographic compared to the members of the control group. To indicate the significance of the statistical differences between the arithmetic averages, a Multivariate Analysis of Covariance (MANCOVA) was used for the domains, and a Univariate Analysis of Covariance for the total score, as shown in **Table 7**.

Table 7. Multivariate Analysis of Covariance (MANCOVA) of the Effect of Infographic Teaching on the Scores of Tenth Grade Students in the Computer Thinking Skills Test.

Contrast Source	Domains	Sum of Squares	Degrees of Freedom	Average of Squares	Value of "F"	Statistical Significance	Impact Size
MANCOVA	The skill of sequencing and arranging	1.180	1	1.180	2.305	0.132	0.025
	Abstraction skill	1.456	1	1.456	3.512	0.064	0.037
	Generalization skill	9.647	1	9.647	19.783	0.000	0.179
	Analysis skill	7.656	1	7.656	13.839	0.000	0.132
	The skill of selection and correction of errors	13.125	1	13.125	22.246	0.000	0.196
	Pattern and relationship recognition skill	7.317	1	7.317	15.464	0.000	0.145
	Algorithmic thinking skill	7.186	1	7.186	13.524	0.000	0.129
Group	The skill of sequencing and arranging	24.267	1	24.267	47.406	0.000*	0.343
	Abstraction skill	15.567	1	15.567	37.557	0.000*	0.292
	Generalization skill	42.464	1	42.464	87.080	0.000*	0.489
	Analysis skill	24.384	1	24.384	44.076	0.000*	0.326
	The skill of selection and correction of errors	27.653	1	27.653	46.871	0.000*	0.340
	Pattern and relationship recognition skill	13.382	1	13.382	28.281	0.000*	0.237
	Algorithmic thinking skill	27.857	1	27.857	52.424	0.000*	0.366
Error	The skill of sequencing and arranging	46.583	91	0.512			
	Abstraction skill	37.719	91	0.414			
	Generalization skill	44.375	91	0.488			
	Analysis skill	50.344	91	0.553			
	The skill of selection and correction of errors	53.688	91	0.590			
	Pattern and relationship recognition skill	43.060	91	0.473			
	Algorithmic thinking skill	48.356	91	0.531			
Overall total	The skill of sequencing and arranging	77.960	99				
	Abstraction skill	63.390	99				
	Generalization skill	98.750	99				
	Analysis skill	81.000	99				
	The skill of selection and correction of errors	100.190	99				
	Pattern and relationship recognition skill	71.840	99				
	Algorithmic thinking skill	84.190	99				

*: Statistically significant at the significance level (0.05).

It is evident from **Table 7** that there are statistically significant differences at the significance level ($= 0.05$) attributed to the effect of the group in testing computational thinking skills according to the group (experimental and control).

It is evident from **Table 8** that there are statistically significant differences at the significance level ($= 0.05$) attributed to the effect of teaching with infographics, where the (F) value reached (138.074), with a statistical significance of (0.00). The differences favored teaching with infographics, and the effect size (η^2) was (0.587), meaning that (58.7%) of the variance in the performance of tenth-grade students in the computer thinking skills test in geography is attributed to the study unit designed based on infographics. This indicates that the impact of the designed educational unit is substantial and strong, as Cohen (1988) indicated that an effect explaining approximately ($\eta^2 = 0.01$) of the total variance indicates a weak effect, while an effect explaining ($\eta^2 = 0.06$) of the total variance indicates a medium effect, and an effect explaining ($\eta^2 = 0.14$) of the total variance indicates a high effect. The researcher attributes this result to the characteristics of the infographic technique, which provides a presentation of the subjects of the unit lessons in the form of images, mind maps, and short texts in a simple and engaging manner without the need to

read texts. It represents stimuli and rich visual communication tools with a specific language for communication and interaction, having its meanings and implications, and educational and instructional methods of use, making it easier for students to memorize, encode, and retrieve information easily. It reflects a contribution to the development of computer thinking skills by focusing on skills and concepts, thereby enhancing students' ability to link and organize information and retain it for a longer time. This aligns with the information processing theory, which emphasizes that the visual stimuli to which students are exposed (such as images and drawings) provide them with understanding and perception effectively, whereas the visual presentation of lessons through infographics aids in acquiring information and concepts, encoding, storing, retrieving, and how to employ them in thinking processes and problem-solving Domínguez Romero and Bobkina^[31]. This aligns with Gestalt theory, which posits that insight is the essence of the educational process, helping students avoid confusion in concepts when exposed to similar situations formed by previous experiences through learning Zhao and Pan^[32]. The results of this question are consistent with the findings of the study by Al-Sharif and Al-Subaie^[19] and the study by Al-Faqra^[20]. They differ from the results of the study by Aguilar and Panov^[21].

Table 8. One-Way ANCOVA Analysis of the Effect of Teaching with Infographics on the Scores of Tenth-Grade Students in the Computational Thinking Skills Test.

Contrast Source	Sum of Squares	Degrees of Freedom	Average of Squares	Value of "F"	Statistical Significance	Impact Size (η^2)
Pre-measurement	69.941	1	69.941	8.337	0.005	0.079
Teaching method	1158.266	1	1158.266	138.074	0.000	0.587
Error	813.705	97	8.389			
Adjusted total	2020.960	99				

*: Statistically significant at the significance level (0.05).

3.2. The Results Related to the Second Question

Are there statistically significant differences at the significance level ($\alpha = 0.05$) in the scores of the linguistic cognitive skills test among tenth grade students attributed to the teaching method (infographic and traditional), gender, and the interaction between them? To answer this question, the arithmetic averages, standard deviations, and adjusted arithmetic averages of the scores of tenth-grade students on the computer thinking skills test were extracted, according

to the group variable (experimental and control), gender, and the interaction between them, and **Table 9** illustrates this:

It appears from **Table 9** that there are apparent differences between the arithmetic averages and the adjusted arithmetic averages of the scores of tenth-grade students on the Computer Thinking Skills Test, as well as gender and the interaction between them, and to determine the significance of the statistical differences between the arithmetic averages, a Two-way ANCOVA analysis was used, as shown in **Table 10**.

Table 9. The Arithmetic Averages and Standard Deviations of the Scores of Tenth-Grade Students on the Computer Thinking Skills Test, According to the Teaching Method Using Infographics, Conventional Method, Gender, and the Interaction between them.

Group	Gender	Number	Pre-Measurement		Post-Measurement		Adjusted Average	Standard Error
			Arithmetic average	Standard deviation	Arithmetic average	Standard deviation		
Experimental	Male	20	9.30	3.47	17.85	2.43	17.27	0.43
	Female	26	8.35	2.08	16.65	2.13	10.38	0.40
Control	Male	26	9.15	3.45	10.50	4.03	14.08	0.43
	Female	28	8.82	1.93	10.32	2.94	13.57	0.40

Table 10. Analysis of Covariance (Two-Way ANCOVA) of the Post-Test Scores of Tenth-Grade Students on the Computer Thinking Skills Test, According to the Variable of Group (Experimental and Control) and Gender.

Contrast Source	Sum of Squares	Degrees of Freedom	Average of Squares	Value of "F"	Statistical Significance	Impact Size (η^2)
Pre-measurement	61.951	1	61.951	7.310	0.008	0.071
Teaching method	1164.846	1	1164.846	137.451	0.000*	0.591
Gender	6.235	1	6.235	0.736	0.393	0.008
Group* Gender	3.163	1	3.163	0.373	0.543	0.004
Error	805.091	95	8.475			
Adjusted total	2020.960	99				

*: Statistically significant at the significance level (0.05).

It is evident from **Table 10** that there are statistically significant differences at the significance level ($= 0.05$) in the post-test scores of the study sample regarding computational thinking skills among tenth-grade students in the geography curriculum according to the group. The value of (F) reached (137.451) with a statistical significance of (0.000), which is statistically significant, indicating the presence of an effect from the unit designed with infographics. Furthermore, it is clear from **Table 10** that the effect size of the teaching method was substantial, as the value of Eta squared (η^2) accounted for (59.1%) of the explained variance (predicted) in the dependent variable, which is the instructional unit designed based on infographics for tenth-grade students in the subject of geography. Additionally, **Table 10** shows that there are no statistically significant differences at the significance level ($= 0.05$) based on the gender variable, where the value of (F) was (0.736) with a statistical significance of (0.393). It was also found that there are no statistically significant differences at the significance level ($= 0.05$) attributed to the interaction effect between the group and gender, as the value of (F) was (0.373) with a statistical significance of (0.543). The researchers attribute this result to the use of images, drawings, and various shapes as they are suitable for developing computational thinking skills. The educational unit designed by the researcher, based on infographics using images, graphical shapes, and drawings, had a positive impact on presenting

ideas, texts, and skills related to computational thinking in an organized and engaging visual format. This approach captures the students' attention and interest due to its reliance on visual representation rather than verbal language. This implies that recalling visual memory is easier for students than recalling verbal memory, which assists them in translating what they see from visual stimuli represented by images, shapes, and symbols into verbal meanings. This result can be explained by the significant effect that using infographics has within the classroom environment, where students move from the usual routine of the educational process to an atmosphere filled with excitement, interaction, reinforcement, and various methods of conveying information. The use of infographics in teaching academic courses contributes to providing students with more information and skills with less time and effort, enhancing their ability to retrieve information effectively when needed, and increasing their motivation to engage in the educational process, which contributes to improving their academic achievement. The results of this question align with the findings of the studies by Al-Marsafi^[23], and Al-Gherbawy^[24].

4. Recommendations

In light of the results reached by the study, it recommends the following:

- The need to integrate graphic information technologies—whether static, dynamic, or interactive—into language-based education across educational levels, as a means of enhancing cognitive language skills, promoting multimedia teaching strategies, and improving student engagement and learning outcomes.
- The need to train teachers to design and implement educational materials based on graphic information and visual education techniques to support the integration of visual culture into educational practices, enhance cognitive linguistic processing, and improve students' academic performance.
- The study recommends reviewing and enriching the content of social studies curricula across educational levels by incorporating multimedia and visually oriented materials to enhance higher-order thinking skills such as visual and cognitive-linguistic abilities essential for language-based learning.

Author Contributions

The researchers conceptualized the study, developed its theoretical framework, and designed its methodology. They reviewed the study literature, collected relevant data, and analyzed and interpreted the data. The first researcher prepared the initial manuscript draft and was responsible for subsequent revisions and final approval of the submitted version.

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Institutional Review Board Statement

The researchers confirm that all procedures performed in this study involving human participants were in accordance with ethical standards for research.

Informed Consent Statement

All participants were fully informed of the study's objectives, procedures, and potential benefits and were assured that their participation was completely voluntary.

Data Availability Statement

The data collected and analyzed in this study, including the statistical tools and results extracted using SPSS, are available. These data can be obtained from the corresponding author upon reasonable request, ensuring that the confidentiality and privacy of participants' information is maintained.

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Conflicts of Interest

The authors declare that there is no conflict of interest, whether financial, professional, or personal, that could have influenced the preparation, results, or publication of this research.

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